Perchlorate in Arizona

Occurrence Study of 2004

PERCHLORATE IN ARIZONA:
OCCURRENCE STUDY OF 2004

Arizona Department of Environmental Quality, Stephen Owens, Director
Arizona Department of Health Services, Catherine Eden, Director
Arizona Department of Water Resources, Herb Guenther, Director
Arizona Department of Agriculture, Don Butler, Director

December 2004

ADDENDUM

Perchlorate Report for 2004

Issued 12/10/2004

Page 1, under Participating Agency Staff, for ADEQ, insert "James Dubois," after "Aguilar,".

Page 25, paragraph 4, line 2, replace "4" with "6".

Table of Contents

Perchlorate Task Force

Arizona Department of Environmental Quality
Stephen Owens, Director

Arizona Department of Health Services
Catherine Eden, Director

Arizona Department of Water Resources
Herb Guenther, Director

Arizona Department of Agriculture
Don Butler, Director

Participating Agency Staff

Jeffrey Stuck, ADEQ Coordinator

ADEQ: Shaunel Aguilar, Amanda Fawley, Susan Fitch, Steve Franchuk, Jennifer Hickman, Lee Johnson, Lin Lawson, Angela Lucci, Douglas McCarty, Lisa Rowe, Linda Taunt, Doug Towne, R. Scott Williams

ADHS: Andrea Domanik, Don Harrington, Will Humble

ADWR: Tracey Carpenter, David Christiana, Don Gross, Tricia McClain, Brett Shaner, Drew Swieczkowski

ADOAg: Jack Peterson

This page left blank intentionally

Executive Summary

In March 2004, the Directors of the Arizona Department of Environmental Quality (ADEQ), Arizona Department of Health Services(ADHS), Arizona Department of Water Resources(ADWR), and Arizona Department of Agriculture(ADOA) convened an inter-agency taskforce to assess the extent and impact of perchlorate contamination in water sources in Arizona, including the Colorado River, and identify actions the State might take to ensure Arizona water resources remain safe to use. ADEQ served as the lead agency for the task force.

Perchlorate is an oxidizer component and a primary ingredient in solid propellants for rockets, missiles, and fireworks. It has industrial uses including airbag inflators, pyrotechnics, and matches. The primary source of perchlorate in the Colorado River comes from manufacturing operations at the Kerr- McGee facility near Henderson, Nevada where large amounts of process water containing perchlorate were discharged into unlined evaporation ponds. Over time the aquifer beneath the facility became contaminated with high levels of perchlorate. That aquifer, underlying the Las Vegas Wash, discharges to Lake Mead and then, the Colorado River main stem. Active remediation at the source has reduced the contaminant load to the Las Vegas Wash from a high of 1,200 pounds per-day (lbs/day) to less than 200 lbs/day.

Focus of the Perchlorate Taskforce

The taskforce focused its efforts in four primary areas:

- Conducting a comprehensive assessment of perchlorate occurrence in Arizona waters to determine its existence and concentration;
- Evaluating the findings of the National Academy of Sciences report from the *Committee to Assess the Health Implications of Perchlorate Ingestion* to understand the potential risk to human health;
- Considering the adequacy of Arizona's existing Health Based Guidance Level for perchlorate and whether it should be modified; and
- Evaluating the effect of perchlorate in water used for Arizona agriculture.

Summary of Perchlorate Occurrence

The results of this most recent assessment of perchlorate in Arizona's waters indicate that, while perchlorate is present in certain areas of the state, the concentrations in water bodies not associated with industrial sites are generally well below the Arizona Health Based Guidance Level (HBGL) of 14 parts per billion (ppb). An HBGL is an advisory level established by ADHS that reflects a maximum concentration of perchlorate in drinking water that can be consumed without resulting in adverse health effects. Perchlorate is classified as an unregulated contaminant by the U.S. Environmental Protection Agency (EPA), meaning there is no water quality standard for perchlorate.

Over 100 water samples from various locations were collected and analyzed to determine the extent to which perchlorate has impacted Arizona's water resources. Because the taskforce was concerned that the extensive direct and indirect recharge of Colorado River water throughout central Arizona, beginning in the early 1990s to the present, may have had the unintended consequence of spreading perchlorate contamination, special attention was directed to monitoring these sites. Sampling locations included surface waters, groundwater, agriculture irrigation water, groundwater recharge facilities, wastewater treatment plant effluent, and man-made water impoundments. The results of this occurrence study generally reflect perchlorate concentrations ranging from non-detection to 7.4 ppb, with one sample in a groundwater monitoring well in Yuma at 15 ppb. These results, show an overall steady decline from perchlorate levels measured in 1999, which ranged from non-detection to 11 ppb.

Comparing these 2004 sampling results to the earlier ones suggests that the remedial efforts in place at the source of perchlorate contamination at the Kerr- McGee site in Nevada is resulting in a slow, steady decline in perchlorate concentrations in both surface and groundwater along the Colorado River as well as in areas using Colorado River water in central and southern Arizona. While overall concentrations of perchlorate are declining, both surface and groundwater concentrations appear to exhibit some seasonal variability. The impacts of seasonal variation and drought on perchlorate concentrations are unknown and beyond the scope of this study.

There are a number of industrial and military sites in Arizona where water resources have been contaminated by perchlorate, and in contrast to other waters, perchlorate levels in water bodies associated with these sites remain high. Cleanup efforts at these sites are underway, with oversight for these cleanups provided by ADEQ and in some instances, EPA. Perchlorate concentrations at these sites are shown separately in this report.

Summary Recommendations

1. Continue State monitoring of critical components of Arizona's water management strategy to gain a better understanding of fate and transport of perchlorate at underground storage facilities and in aquifers showing signs of impact.
2. Review the final National Academy of Sciences evaluation of the EPA study, when it is released, to determine if Arizona should revise its HBGL for perchlorate.
3. Continue State oversight of remediation work at industrial and military sites identified in this report.
4. Continue to monitor research efforts on the effect of perchlorate in food and any related risks to public health.

Perchlorate in Arizona Occurrence Study

Perchlorate contamination of Arizona soil and water has occurred primarily near users of perchlorate salts, including military bases, aerospace installations, and defense contractors that build rockets. Certain types of sodium nitrate fertilizer produced in Chile also contain perchlorate salts, making industries that use these imports susceptible to contamination. Perchlorate has been found in surface and groundwater supplies in Arizona, California and Nevada, and in at least 22 additional states throughout the nation. The primary source of perchlorate in the Colorado River comes from manufacturing facilities near Henderson Nevada, currently owned by Kerr McGee Corporation. Large amounts of process wastewater containing perchlorate have been discharged into unlined evaporation ponds at these facilities. Over time the aquifer beneath the facility and the ponds became contaminated with high levels of ammonium perchlorate. The groundwater from that aquifer seeps into the Las Vegas Wash which drains into Lake Mead and ultimately into the Colorado River as it flows through the Hoover Dam. Detectable concentrations of perchlorate have been found along the river from Lake Mead to the international boundary near Yuma. Since the discovery of perchlorate in the Colorado River in 1997, several studies have occurred to assess the extent of the contamination.

ADEQ conducted the first Perchlorate Occurrence Study of Arizona Water Resources in 1999. Monitoring conducted on the Colorado River, Central Arizona Project Canal, and various groundwater sources throughout the Phoenix metropolitan area showed perchlorate levels ranging from 480 parts per billion (ppb) in Lake Mead to between 11 ppb and non-detection along the Colorado River main stem and the Central Arizona Project (CAP).

Subsequent to the 1999 Perchlorate Occurrence study, the City of Phoenix conducted a second round of perchlorate monitoring, in 1999 and 2000, at the same sample locations along the Colorado River and within the City of Phoenix drinking water system. The result of this monitoring continued to show perchlorate detections along the Colorado River and Central Arizona Project Canal, however, the levels of perchlorate were reducing in concentration.

Full scale remediation at the Kerr-McGee - Henderson site did not begin until 2002. As of May, 2004, more than 1,700 pounds of perchlorate are removed every day from groundwater. Kerr-McGee, under a voluntary partnership with EPA Region 9 and the Nevada Division of Environmental Protection, has constructed a multi-pronged remedial system, which intercepts and treats groundwater at three different locations before it enters the Las Vegas Wash. In 2003, the average perchlorate level measured at the Saddle Island drinking water intake in Lake Mead was 9.87 ppb. Reduction of releases from the source in Henderson, Nevada should result in further declines in detectable perchlorate seen in the Colorado River and the CAP.

2004 PERCHLORATE OCCURRENCE ASSESSMENT OF ARIZONA WATER RESOURCES

The taskforce identified a need for a current assessment of the occurrence of perchlorate in Arizona waters. The evaluation involved: (1) the review of existing data from studies by ADEQ and other agencies monitoring for perchlorate; and (2) the collection of new data from a broader selection of sampling locations than included in previous studies to ascertain current levels throughout the state.

The task force identified over 100 prospective monitoring locations with either the potential to introduce perchlorate into Arizona's water supplies or could be used as background sites. These included surface waters along the Colorado River and man-made recreational impoundments; canals; wells; agricultural areas and groundwater recharge projects. These resources use Colorado River water and represent pathways into Arizona's water resources that had yet to be evaluated for the presence of perchlorate. This assessment performed by the Task Force is the most comprehensive perchlorate occurrence evaluation that has been conducted in Arizona to date.

The results of the assessment are provided in text, tabular and graphic formats. Data collected prior to 2004 has been presented separately from earlier data due to recent improvements in the laboratory methods. Since 1999, EPA has continued to improve the accuracy of the analytical methods for perchlorate which have resulted in lower detection limits and better isolation from laboratory interferences during analysis. Since 1999, the analytical detection level for perchlorate has gone from 200 ppb to 1 ppb.

Sampling Program

The water quality monitoring project was a joint effort conducted by the Departments of Environmental Quality and Water Resources. A sampling and analysis plan was developed in accordance with Arizona's credible data requirements (A.A.C. R18-11-602) and included data quality objectives for the study. The sampling and analysis plan is provided in Appendix A.

Final sampling locations were chosen based on several factors. Initial areas were identified as susceptible to perchlorate contamination based on proximity to certain activities or land use practices such as the underground storage of Colorado River water or use of river water for irrigation purposes. Additional sites were selected due to their isolation from activities or land use practices commonly associated with perchlorate and, therefore, serve as "background" sites. Lastly, a number of sites were sampled because past analyses indicated elevated levels of perchlorate; this sampling round would help determine if levels at these locations were increasing or decreasing.

Figure 1 shows the locations of sampling conducted by the task force. The numbers correspond to the table in Appendix B which provides the map number, site location, source of water, latitude and longitude; county; whether it is a new or existing sampling site; the program responsible for sampling, and the results. The final list included a broad cross-section of locations: lakes, domestic water supply wells, agricultural wells in areas where Colorado River water is used for irrigation, municipal drinking water supplies, urban impoundments, concentrated animal feeding operations (CAFOs), ADWR permitted underground storage facilities, and the Salt River Project and Central Arizona Project canals.

Sample collection was conducted by monitoring staff from ADEQ and ADWR between May and August of 2004. The majority of the samples collected were submitted to Del Mar Analytical Laboratory in Phoenix for analysis. Split samples for quality control/ quality assurance (QA/QC) purposes were sent to Montgomery Watson Laboratories in Los Angeles, CA; both laboratories are ADHS certified laboratories. All samples were analyzed using a modified EPA Method 314 with a reporting limit of two ppb.

Quality control samples were collected to evaluate the collection and handling of samplings, field procedures and reproducibility of analytical results. QA/QC procedures include analysis of blind duplicates, split and spiked samples, trip blanks, and equipment blanks. Sample results were evaluated based on the data quality objectives outlined in the sampling and analysis plan. Of the over 30 QA/QC samples taken, only one sample, a spiked sample, came back slightly above the allowable range.

Results of Task Force Sampling Effort

Figure 2 shows the results of the sampling conducted by the task force. A total of 119 samples (88 separate sampling locations and 31 quality control samples) were collected from the locations shown in Figure 1. The results show perchlorate concentrations range from less than detection (2 ppb) throughout much of the state to 15 ppb in a groundwater monitoring well near Yuma. Tables 1 through 3 display the actual results by site based on type of source water: surface water, groundwater or Colorado River water stored in underground recharge facilities.

<u>Figure 1:</u> Sample Locations

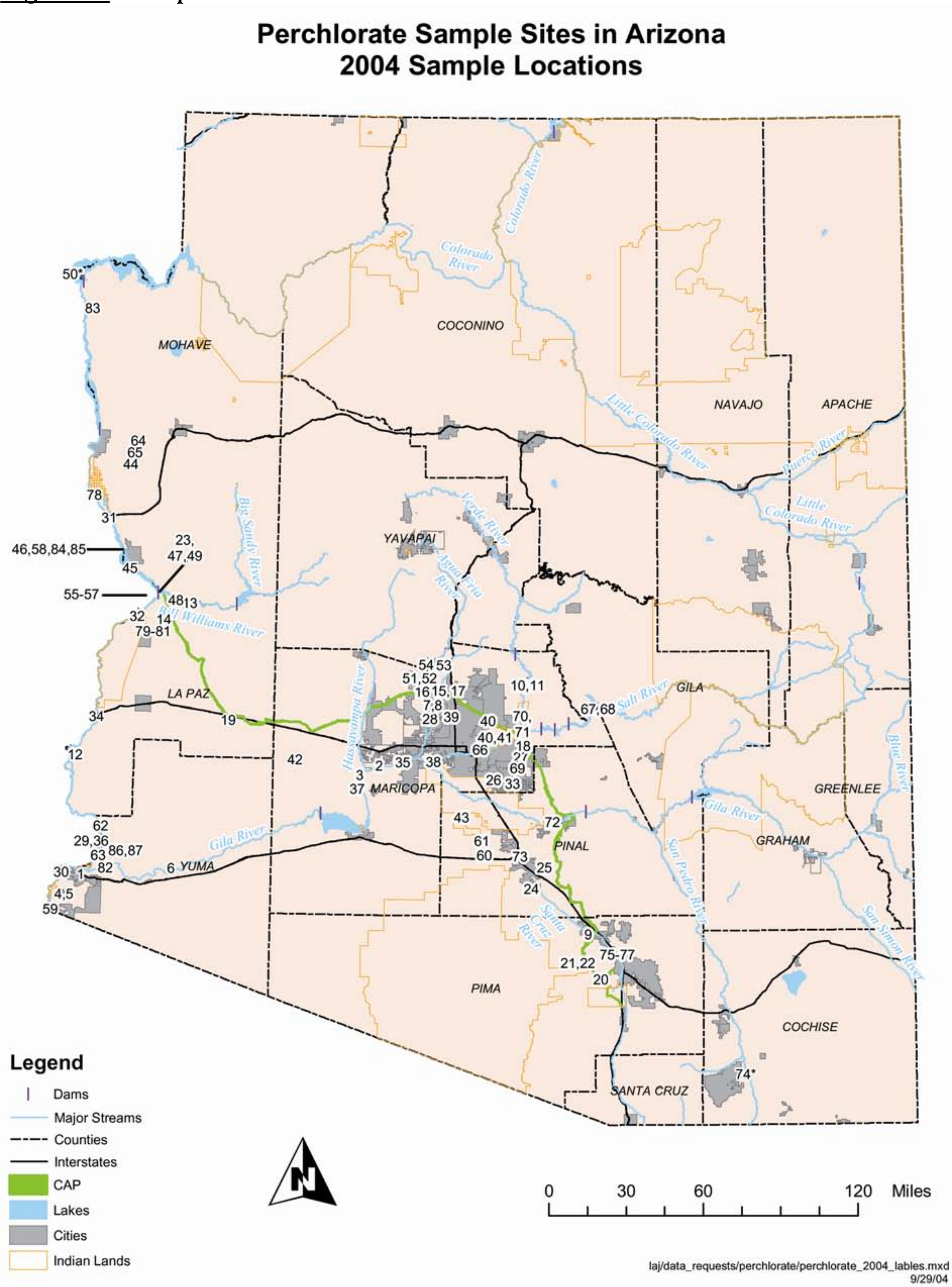

Figure 2: *Sample Results*

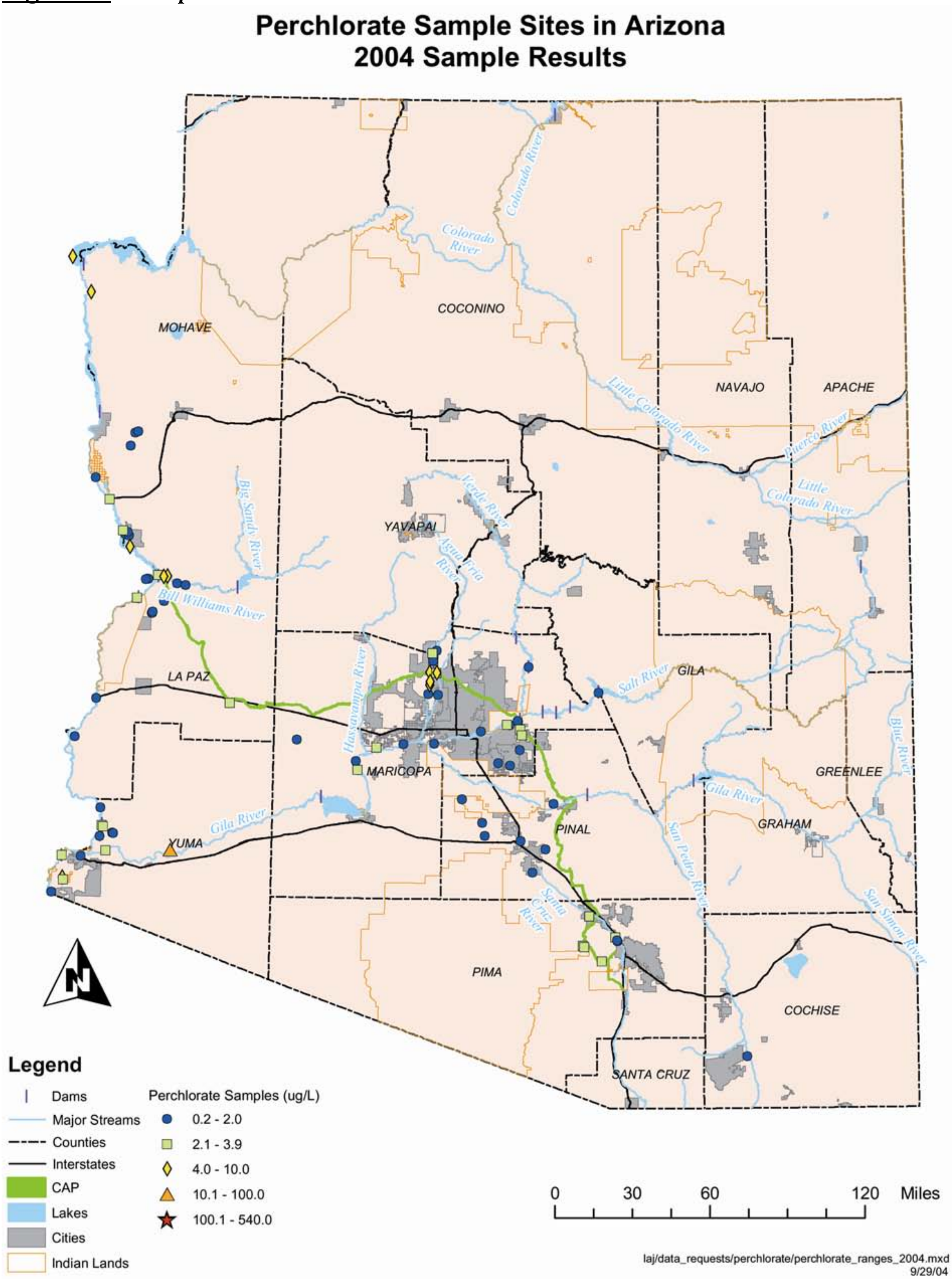

Table 1: Results from Sampling Surface Waters

Map #	Site Location	Site Identification	Date Samples Collected	Results (ppb)	Reporting Limit (ppb)
Colorado River Mainstem from Lake Mead to Mexico					
50	Lake Mead	Saddle Island; AMSWTF raw water	3/31/2004	6.0	2
83	Colorado River	Willow Beach; 11 mi S Hoover Dam	5/7/2004	4.5	2
31	Colorado River	at Topock; sample depth 2 meters	5/19/2004	3.9	2
78	Topock Marsh	below marsh bay; sample depth 1.5 meters	5/19/2004	ND	2
49	Lake Havasu	at Parker Dam; sample depth 9 meters	5/18/2004	3.5	2
45	Lake Havasu	edge of Thompson Bay; sample depth 7 meters	5/18/2004	4.4	2
46	Lake Havasu	riverine portion; sample depth 2 meters	5/18/2004	3.7	2
47	Lake Havasu	near CAP intake; sample depth 2 meters	5/18/2004	4.4	2
48	Bill Williams River	At Mineral Wash	5/11/2004	ND	2
32	Colorado River	above Headgate Rock Dam; sample depth 3 meters	5/17/2004	3.5	2
29	Colorado River	At Imperial dam; sample depth 1 meter	5/17/2004	3.6	2
36	Gila Main Canal	200 yards downstream of diversion for Imperial Dam; sample at surface	5/17/2004	3.3	2
62	Martinez Lake	mid-lake; sample depth 1.5 meters	5/17/2004	ND	2
82	Wellton and Mohawk Canals	At gage near Gila Main Canal	6/15/2004	2.6	2
63	Mittry Lake	mid-lake; sample depth 2 meters	5/17/2004	ND	2
59	Main Outlet Drain (MODE canal)	near San Luis	6/15/2004	ND	2
30	Colorado River	At Morelos Dam; at Highway 95	6/15/2004	2.4	2
Central Arizona Project Canal from Little Harquahala Pumping Plant to terminus and SRP canals					
23	CAP Canal	Wilmer (Havasu) Pumping Plant	2/18/2004	4.2	2
19	CAP Canal	Little Harquahala Pumping Plant	7/7/2004	3.2	2
16	CAP Canal	CAP1; above Lake Pleasant turnout	2/10/2004	4.0	2
51	Lake Pleasant	at dam; sample at surface	6/29/2004	2.2	2
52	Lake Pleasant	at dam; sample depth 4.5 meters	6/29/2004	2.0	2
53	Lake Pleasant	river input	2/10/2004	ND	2
54	Lake Pleasant	mid-lake	2/10/2004	3.0	2
17	CAP Canal	CAP2; below Lake Pleasant	2/10/2004	3.0	2
15	CAP Canal	99th Ave bridge	2/9/2004	4.2	2

70	SRP Arizona Canal	downstream of Granite Reef Dam	6/21/2004	ND	2
71	SRP Southern Canal	downstream of Granite Reef Dam	6/21/2004	ND	2
18	CAP Canal	at McKellips Bridge	7/7/2004	2.7	2
20	CAP Canal	San Xavier Pumping Plant	7/13/2004	2.3	2
Major Arizona Rivers					
37	Gila River	at Gillespie Dam	6/30/2004	ND	2
38	Gila River	below 91st Avenue WWTP outfall	6/30/2004	2.1	2
Not on map	Santa Cruz River	downstream of Nogales IWWTP at RR crossing	6/24/2004	<20 [2]	20
74	San Pedro River	Near Charleston	6/24/2004	ND	2
75	Santa Cruz River	downstream of Roger Rd WWTP	6/24/2004	<4 [1]	4
Reservoirs and Urban Impoundments					
10	Bartlett Lake	at dam; sample depth at surface	7/7/2004	ND	2
11	Bartlett Lake	at dam; sample depth 3.8 meter	7/7/2004	ND	2
27	City of Mesa Red Mountain	mid-lake; sample depth 0.3 meters	5/12/2004	2.9	2
66	Papago Park Lakes	mid-lake; sample depth 0.3 meters	5/12/2004	ND	2
68	Roosevelt Lake	at dam; sample depth at surface	6/3/2004	ND	2
67	Roosevelt Lake	at dam; sample depth 30 meters	6/3/2004	ND	2

Notes:
1: sample required 2X dilution resulting in a higher reporting limit
2: sample required 10X dilution resulting in a higher reporting limit – not included in Figure 2 due to the high reporting limit

Surface Water: Forty one samples were collected by the task force in surface waters throughout the state. The results are shown in Table 1 and are grouped as follows: sites along the Colorado River mainstem from Lake Mead to the Northern International Boundary with Mexico; key locations along the CAP Canal from the Wilmer Pumping Plant to its terminus in Tucson and two locations on the Salt River Project canal system; major rivers throughout the state; and major reservoirs in the state as well as several urban impoundments.

Perchlorate is present in the Colorado River but steadily decreases in concentration from 6 ppb at Lake Mead to 2.4 ppb at Morelos Dam. Concentrations at Willow Beach, approximately 11 miles below Hoover Dam, have gradually declined from about 10 ppb in 1999 to 4.5 ppb during this study. The lowest concentrations found at Willow Beach were 3.4 ppb in September, 2003 and 3.0 ppb in October, 2003. The result of 4.5 ppb suggest a possible seasonal or drought related component to perchlorate mitigation. Perchlorate is present in the main stem of the river at Topock, throughout Lake Havasu, and in the Lower Colorado River which is diverted into canals for use in agriculture in and around Yuma before crossing into Mexico at Morelos Dam. It was not found in backwaters to the main stem of the river such as in Topock Marsh, Martinez Lake, Mittry Lake or in the Bill Williams River upstream of Lake Havasu.

Perchlorate concentrations of 2.6 ppb were found in the Wellton/Mohawk Canal system, which is fed with Colorado River water near Imperial Dam to provide water to agriculture in the Wellton Valley. Results from the Main Outlet Drain Extension (MODE) canal were less than detection which suggests perchlorate may not be present in agricultural return flows, the primary source of water in the MODE, or there may have been additional sources of water present in the MODE at the time of sampling.

The Wilmer Pumping Plant, intake for the CAP Canal, draws water from the Colorado River near Parker. Results from the task force sampling showed concentrations of 4.2 ppb, down from the historic highs of over 9 ppb in 1998. Peak levels of perchlorate at the pumping plant have declined gradually but steadily since remediation began in Las Vegas Wash in 1999. Perchlorate concentrations along the CAP Canal reflect the concentrations detected at the canal intakes and gradually decrease along the way. Concentrations were 3.2 ppb at the Little Harquahala Pumping Plant, 2.7 ppb at the McKellips Bridge and 2.3 ppb at the San Xavier Pumping Plant, just upstream of the terminus of the system inTucson.

Generally speaking, perchlorate is not found in the major river systems within Arizona. One site on the Gila River near Gillespie Dam had a result of 2.1 ppb, just above the reporting limit. This site also receives significant municipal wastewater from Phoenix and other Valley communities and agricultural return flows from the Buckeye area. Samples from both locations along the Santa Cruz River required multiple dilutions due to turbidity in the samples; this resulted in significantly higher reporting limit for those samples. These samples were included in the table but not on Figure 2 as they would appear anomalous compared to the other data. Perchlorate is also present in urban impoundments used for seasonal storage of Colorado River water (e.g., Red Mountain Lake, Lake Pleasant); at concentrations generally reflective of this source. Results from background sites such as Papago Park, Bartlett and Roosevelt Lakes showed no perchlorate present.

Table 2: Results from Sampling Groundwater – by county

Map #	Site Location	Site Identification	County	Date Samples Collected	Results (ppb)	Reporting Limits (ppb)
65	N. Mohave Water Co. #9	#55-589061	Mohave	6/9/2004	ND	2
64	N. Mohave Water Co. #7	ADEQ # 21807	Mohave	6/9/2004	ND	2
58	Lucas Domestic Well	ADEQ # 22421	Mohave	6/9/2004	<4[1]	4
84	Yoney Auto Shop	ADEQ # 60606	Mohave	6/9/2004	ND	2
85	Yoney Domestic Well	ADEQ # 60969	Mohave	6/9/2004	ND	2
44	Horvath Domestic Well	ADEQ # 60592	Mohave	6/9/2004	ND	2
55	LHC Monitoring Well #MW-2B	ADEQ # 51677	Mohave	6/9/2004	ND	2
57	LHC Monitoring Well #MW-9B	ADEQ #51681	Mohave	6/9/2004	ND	2
56	LHC Monitoring Well #MW-5B	ADEQ #51674	Mohave	6/9/2004	ND	2
13	Bill Williams Watershed	at Planet Ranch	Mohave	5/11/2004	ND	2
80	Town of Parker #7	ADEQ # 19544	La Paz	6/10/2004	ND	2
79	Town of Parker #6	ADEQ # 19537	La Paz	6/10/2004	ND	2
81	Town of Parker #8	ADEQ # 19352	La Paz	6/10/2004	ND	2
14	Buckskin State Park	near Parker #55-616549	La Paz	6/10/2004	ND	2
34	Ehrenberg area	GW well	La Paz	6/16/2004	ND	2
12	Ben Barker	GW well	La Paz	6/16/2004	ND	2
86	Yuma Proving Ground	GW well	Yuma	6/16/2004	ND	2
87	Yuma Proving Ground	GW well	Yuma	6/16/2004	ND	2
6	ADEQ MW-30	ADEQ # 58136	Yuma	6/15/2004	15.0	2
5	ADEQ MW-24	ADEQ # 58046	Yuma	6/15/2004	7.4	2
4	ADEQ MW-12	ADEQ # 57534	Yuma	6/15/2004	3.4	2
1	ADEQ MW-3	ADEQ # 56529	Yuma	6/15/2004	ND	2
42	Harquahala Southwestern	GW well	Maricopa	7/6/2004	ND	2
69	Roosevelt Water Conservation District	#55-620514 9-2 1/4E	Maricopa	6/22/2004	ND	2
2	ADEQ MW-3	ADEQ #56869	Maricopa	6/17/2004	2.5	2
3	ADEQ MW-8	ADEQ #56875	Maricopa	6/17/2004	ND	2
35	Fullmer Cattle Co.	#55-800969 C (01-02)04BAB	Maricopa	6/16/2004	ND	2
33	DeJong Dairy	#55-520547	Maricopa	6/22/2004	ND	2
43	Hogenes Dairy	#55-612160	Pinal	6/16/2004	ND	2
72	San Carlos Irrigation District	D(04-09)29CCB	Pinal	6/17/2004	ND	2
24	Central AZ Irrigation & Drainage District	#55-622495 D(09-07)02CDD	Pinal	6/17/2004	ND	2
25	Central AZ Irrigation & Drainage District	#55-621959 D(07-08)22DDC	Pinal	6/17/2004	ND	2
73	San Carlos Irrigation District	D(07-06)01DDB	Pinal	6/17/2004	ND	2
60	Maricopa Stanfield Irrigation District	#55-615418 D(06-04)27DDD	Pinal	6/16/2004	ND	2
61	Maricopa Stanfield Irrigation District	#55-606186 D(05-04)34DDD	Pinal	6/16/2004	ND	2

Notes: 1: sample required 2X dilution resulting in a higher reporting limit

Table 3: Results from Sampling Groundwater Recharge Facilities – by county

Map #	Site Location	Site Identification	Date Samples Collected	Results (ppb)	Reporting Limits (ppb)
La Paz County – downstream of Wilmer Pumping Plant					
43-P	Vidler Recharge Facility	DG-01	12/3/2003	2.3	2
44-P	Vidler Recharge Facility	DG-02	12/3/2003	ND	2
45-P	Vidler Recharge Facility	UG-01	12/3/2003	4.4	2
Maricopa County – downstream of Lake Pleasant					
7	Agua Fria Managed Recharge Project	MW-2	7/27/2004	4.8	2
8	Agua Fria Managed Recharge Project	MW-3	7/27/2004	4.3	2
26	City of Chandler Tumbleweed Recharge	Obs-3A; #55-570787	6/22/2004	ND	2
28	City of Peoria Beardsley Recharge	MW-2; #55-569358	7/6/2004	ND	2
39	Glendale Arrowhead Recharge		8/12/2004	ND	2
40	Granite Reef Underground Storage	RCMWGR2	6/21/2004	ND	2
41	Granite Reef Underground Storage	RCMWGR3	6/21/2004	2.7	2
Pima County – downstream of Brady Pumping Plant					
2-P	Avra Valley Recharge	CAP inlet	5/13/1999	ND	4
9	Avra Valley Recharge	AVMW-01	7/13/2004	2.4	2
21	CAVSARP	WR262A	7/8/2004	2.4	2
22	CAVSARP	WR314A	7/8/2004	2.3	2
76	Sweetwater Underground Storage	WR-69B	7/8/2004	ND	2
77	Sweetwater Underground Storage	WR-68B	7/8/2004	ND	2

Notes: P denotes pre-2004 sampling; results will be shown on Figure 4.

Groundwater: Thirty five groundwater samples were collected as part of this study and are summarized in Table 2. The sampling focused on wells used for domestic and municipal water supplies along the Colorado River from Bullhead City to Yuma, wells in areas utilizing Central Arizona Project water for irrigation or livestock watering, and wells near concentrated animal feeding operations. Of these, four samples had results above the detection limit of 2 ppb. One sample near Buckeye was slightly above the detection limit at 2.5 ppb. The other three samples with results above detection, ranging from 3.4 ppb to 15 ppb, were found in monitoring wells in the Yuma area and are adjacent to agricultural lands irrigated with Colorado River water (e.g., Chemehuevi Indian Reservation and the Yuma area). Results from a background site, the Bill Williams Watershed at Planet Ranch, showed no perchlorate present. The task force recommends additional confirmation sampling in areas showing impact from perchlorate.

Groundwater Recharge Facilities: Nine groundwater recharge facilities representing different types of source water (e.g., Colorado River water and effluent) and recharge methods (e.g., basins and wells) were sampled as part of this study. The results are summarized in Table 3. These recharge projects serve as a central component for municipal and state water banking strategies, whereby excess Colorado River water is stored in underground aquifers for use during times of drought or excess treated effluent is stored for recovery during times of higher demand. Facilities that recharge Colorado River water had perchlorate concentrations ranging from 2.3 ppb to 4.8 ppb and generally reflect the concentrations of the source water at those locations (see Table 1 for CAP Canal water quality results). Perchlorate was not detected at any treated effluent recharge facility, regardless of the recharge method. The Sweetwater Underground Storage Facility in Tucson and the Beardsley Wastewater Treatment Plant Recharge Facility in Peoria recharge through basins. The City of Chandler's Tumbleweed Recharge Facility and the City of Glendale's Arrowhead Recharge Facility recharge with wells.

The CAP Canal system brings Colorado River water from the Wilmer Pumping Plant near Parker Dam to metropolitan Phoenix and then south to the City of Tucson. Perchlorate concentrations in the canal are following the same declining patterns as seen on the main stem of the river. Levels on the river at the Wilmer Pumping Plant are currently around 4-5 ppb and the results at the first downstream recharge facility, Vidler Water Company, reflect similar concentrations. Similarly, concentrations in Lake Pleasant and the CAP Canal downstream of the lake range between 2.2 and 3 ppb. Perchlorate concentrations in the recharge facilities downstream range from less than detection to 4.8 ppb at the Agua Fria Recharge Project. Concentrations in the CAP Canal from McKellips Bridge to its terminus south of the San Xavier Pumping Plant reflect a downward trend from 2.7 ppb in the metropolitan Phoenix area to 2.3 ppb in Tucson. The recharge projects in Pima County show concentrations just above detection at 2 ppb to 2.4 ppb.

Prior to this study, little to no sampling for perchlorate had been conducted at groundwater recharge projects. The task force recommends the continued monitoring of select underground storage facilities to determine the impacts of long term storage of Colorado River water on the aquifer system. Little is known about how perchlorate behaves in the subsurface. Additional monitoring should also be done peripherally to the projects to determine if there is any lateral migration.

Perchlorate data collected prior to 2004

Figure 3 shows perchlorate sampling locations prior to the task force sampling effort. As noted earlier, these data were separated from the 2004 data because of recent revisions to the analytical method for perchlorate that has resulted in lower detection and reporting limits. Displaying all the data together could have given readers the false impression that concentration levels in certain areas were higher than they actually were.

Figure 3a is an inset map for sampling locations in the Lake Mohave Basin area.

Figure 4 shows the results of these previous sampling efforts which are described below.

In 1999, the ADEQ conducted a perchlorate occurrence study of Arizona water resources. This study was posted on the ADEQ website and included monitoring results of the Colorado River, CAP Canal, and various groundwater sources throughout the Phoenix metropolitan area. This study was performed in April, May, July, August, and September. The report consists of sample results collected from locations primarily focused on Lake Mead and the Colorado River main stem. Results from this report showed perchlorate levels ranging from 480 ppb in Lake Mead to between 11 ppb and non-detection (at that time defined as less than 4 ppb) along the Colorado River main stem, in the CAP system and in drinking water sources.

In 2000 and 2001, the City of Phoenix conducted a second round of perchlorate monitoring at the same sample locations used for the 1999 study. The results of this monitoring showed continued detection for perchlorate along the River and in the CAP Canal, however the overall concentration levels of perchlorate were decreasing. Since perchlorate in the Colorado River was traced to Las Vegas Wash, in 1997, by Metropolitan Water District of Southern California, ADEQ has monitored perchlorate in its ambient groundwater monitoring, especially in those basins adjacent to or where there is significant use of Colorado River water. Perchlorate has only been detected along the Colorado River from Lake Mohave Basin south to the Yuma area. The sampling locations from these previous studies and ADEQ's ambient groundwater program are listed in Appendix C.

Monitoring in Municipal and Domestic Water Systems

Under the Unregulated Contaminant Monitoring Rule (UCMR), all large water systems and a statistical sampling of small systems are required to monitor for perchlorate. Those samples were taken at "points of entry" into the drinking water system rather than at wellheads. This fact and the ability for water systems to blend different sources of water makes it difficult to compare that data with data collected through these occurrence studies.

Sites with known perchlorate contamination

Figure 5 shows recent results from a number of sites with known perchlorate contamination in Arizona. A brief synopsis of each site is given in Table 4. These data were placed on a separate map so as not to skew the results shown on the other maps. These sites are being managed by either the EPA or ADEQ's Waste Programs Division.

<u>Figure 3:</u> Pre-2004 Sample Locations

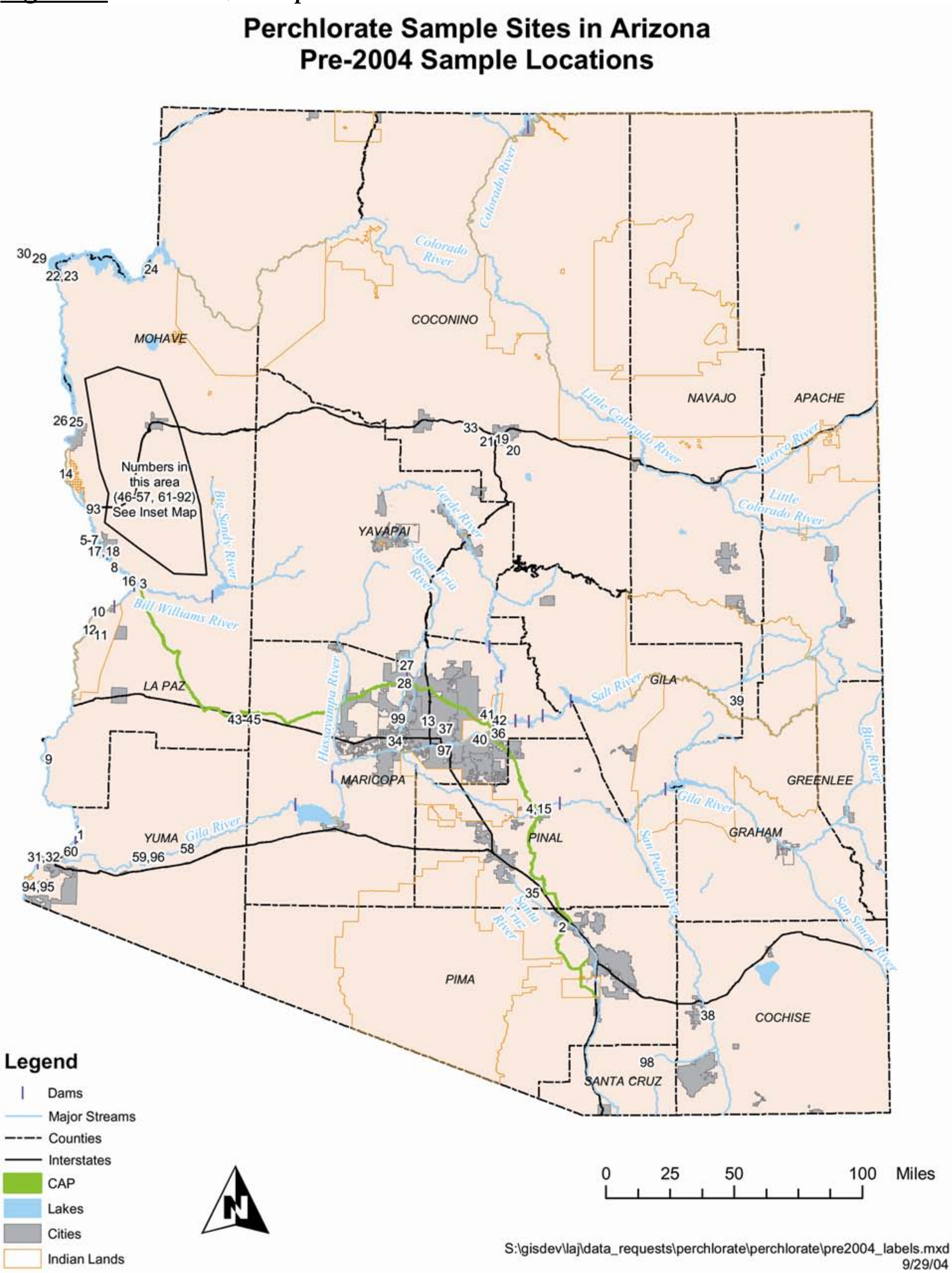

__Figure 3a:__ Pre-2004 Samples

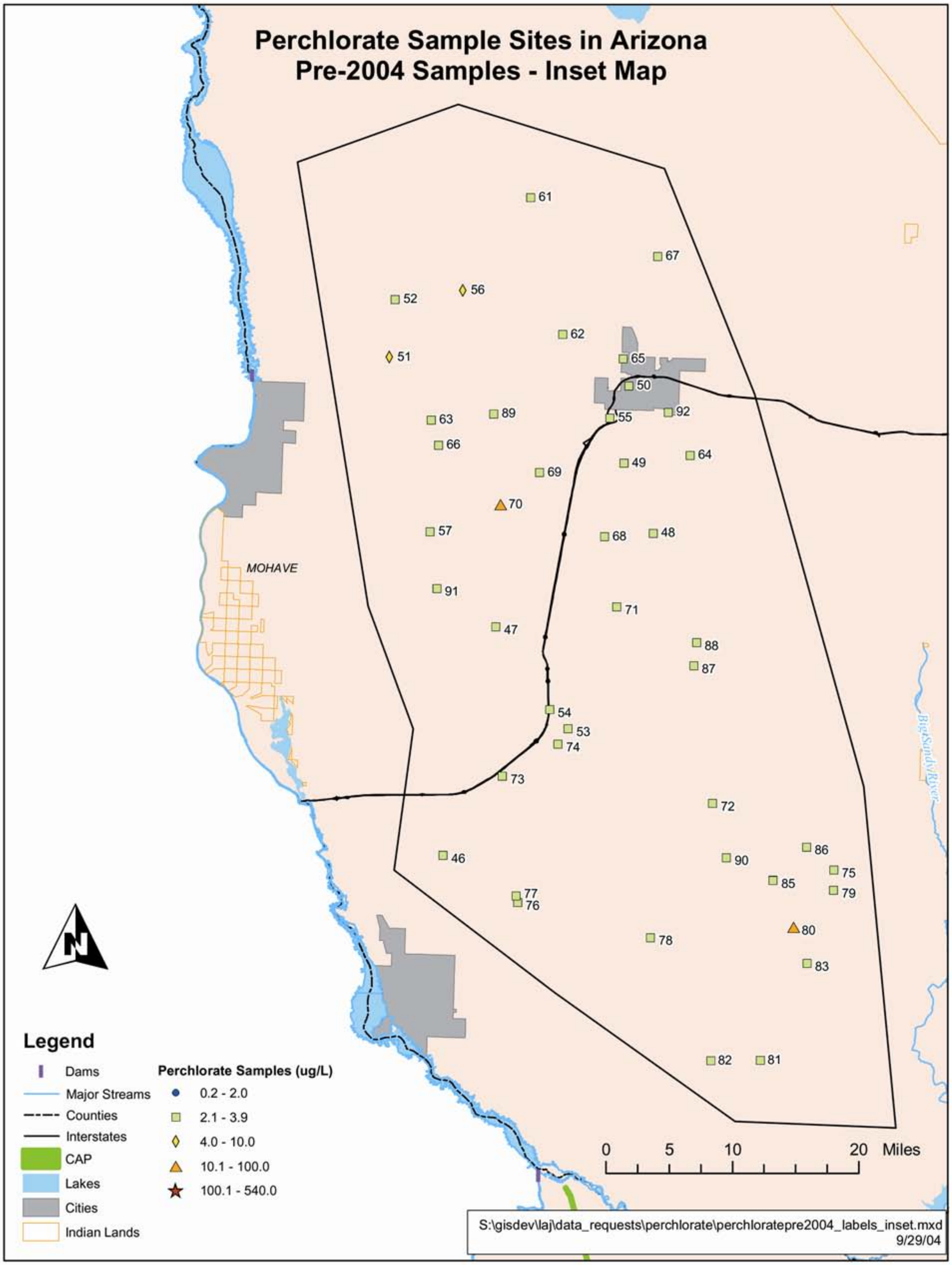

__Figure 4:__ Pre-2004 Sample Results

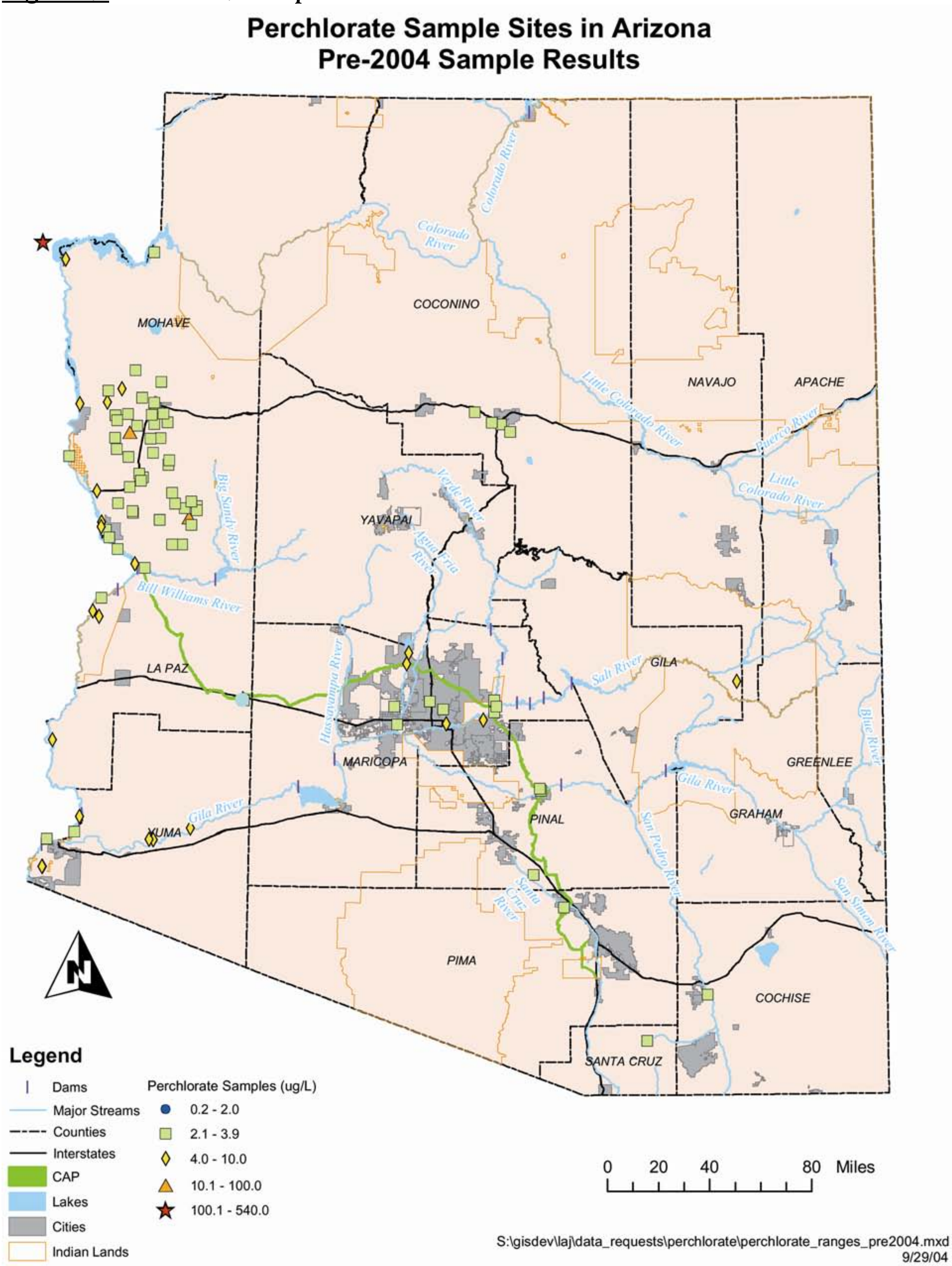

***Figure 5:* Known Sites with Perchlorate Contamination**

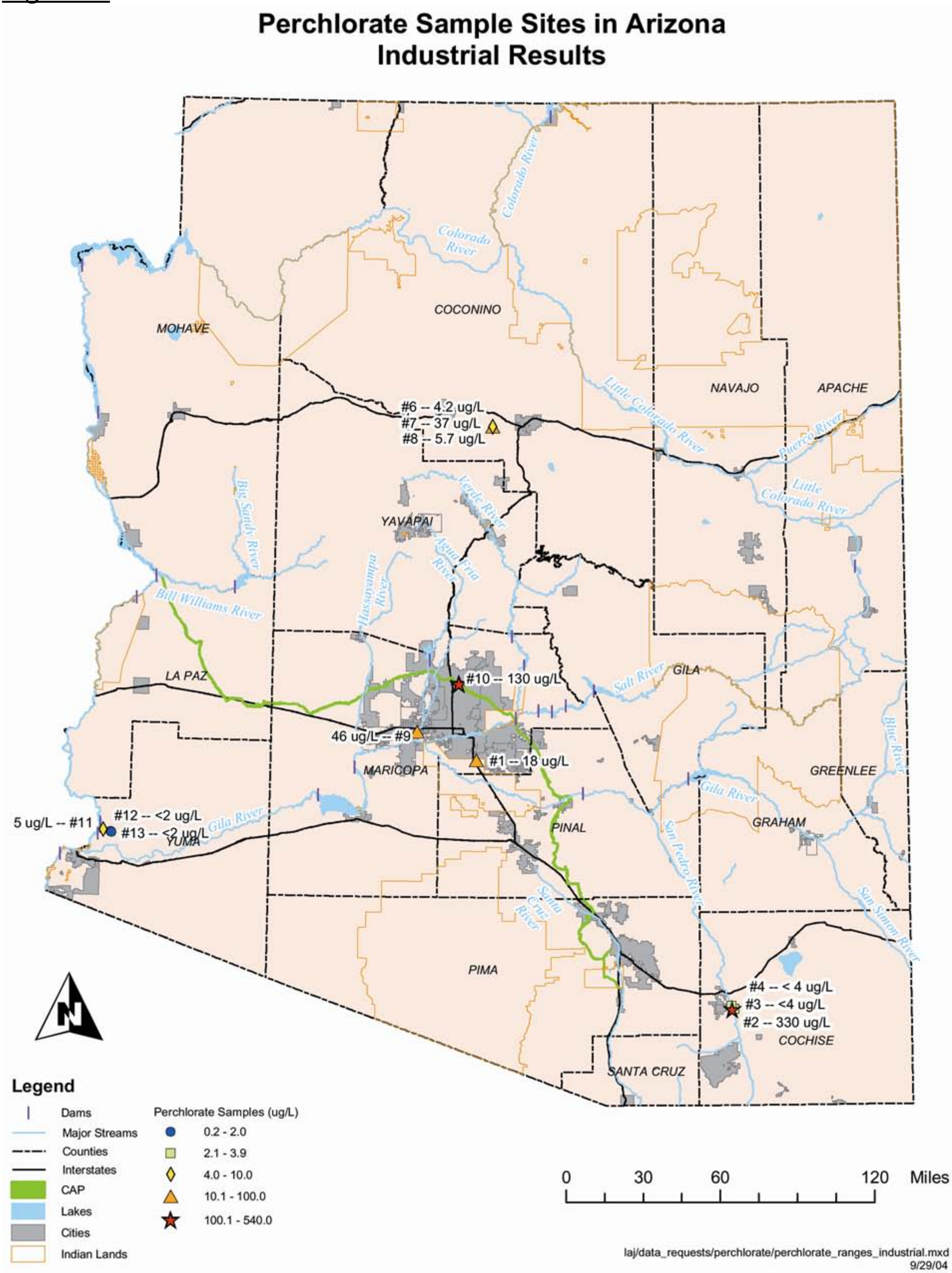

***Table 4:* Known Sites with Perchlorate Contamination**
(Site numbers correspond to Figure 5, unless otherwise noted)

Facility/Location/Map No.	Description
Aerodyne (Site No. 1) East of Lone Butte Industrial Park Chandler, AZ	This facility is located on the Gila River Indian Reservation just east of the Lone Butte Industrial Park. Perchlorate has been detected in groundwater at 18 ppb and is likely related to propellant testing at the facility. The Gila River Indian Community in cooperation with the EPA continues to investigate the extent of the contamination and possible remediation strategies.
Apache Nitrogen (Site Nos. 2, 3, 4) Near St. David, Cochise County, AZ	This site, located south of Benson on the west side of the San Pedro River, is being remediated for significant contamination of groundwater by nitrates. More recently, perchlorate was discovered in a shallow perched aquifer beneath one of the old unlined evaporation ponds. This shallow aquifer overlies clays with are essentially impermeable. Perchlorate levels of 700-800 ppb have been found in this aquifer. The source of the perchlorate was Chilean sodium nitrate fertilizer with impurities of sodium perchlorate. This fertilizer was used by Apache Nitrogen as a feedstock for fertilizer production until 1995. The contaminated perched aquifer feeds a secondary shallow aquifer that eventually extends offsite. Groundwater flow is very slow in the aquifer. To date, an onsite monitoring well at the lower end of the aquifer has not detected perchlorate.
Camp Navajo (Site Nos. 6, 7, 8) Approximately 20 miles west of Flagstaff, AZ off Interstate 40	Camp Navajo is located in Bellmont, AZ, west of Flagstaff on Interstate 40. Formerly known as Navajo Army Depot, the camp was used by the Army for the storage of materials and ordnance, and for the demilitarization and disposal of obsolete or unserviceable conventional ammunition, explosives, and chemical warfare agents. Munitions of many kinds were burned and detonated in the open burn/open detonation area (OBOD) at the site. Previous investigations targeted white phosphorus, TNT and related chemicals. In September, 2002, water that accumulated seasonally in the open detonation pits was sampled for perchlorate. The highest level detected was 37 ppb. The Arizona Game and Fish Department has concerns about elk and other wildlife that drink from these transient pools when water is present. The detections raise additional questions regarding potential groundwater contamination; however depth to groundwater in this area is over 1,200 feet. The cost and logistics of sampling are significant factors in future investigations.

Park Shadows Country Estates (former public water system) *(#34 onFigure #4 (pre-2004 sampling)*	This public water system, located east of the Unidynamics site at the Phoenix-Goodyear Airport, had two wells, a domestic well and a backup irrigation well. As part of the remedial investigation by Unidynamics, Inc, a former tenant, perchlorate was detected in the irrigation well resulting in closure of the well as a PWS supply and eventually decommissioning of the well as it was providing a direct conduit to clean groundwater. The maximum perchlorate level measured in this well was 72 ppb. Eventually perchlorate was detected in the domestic well, at a maximum level of 130 ppb. This prompted closure of the well and hookup to the Goodyear PWS.
Unidynamics Phoenix, Inc. (Site No. 9) At the former Phoenix-Goodyear Airport in Goodyear, AZ (17 west of Phoenix)	The former Unidynamics Phoenix, Inc. facility is located on 58 acres in the north portion of the former Litchfield Airport (later known as Phoenix-Goodyear Airport) in Goodyear, AZ. The facility was operated as a research, design, development, testing, and assembly plant of ordnance components and related electromechanical devices. It was discovered in 1998 that groundwater has been contaminated by solvents and perchlorate. To date, the highest perchlorate levels measured in groundwater monitoring wells is 130 ppb. As part of the remedial activities, Crane Co. is required to monitor for perchlorate in private wells in the area. In cooperation with the City of Goodyear, Crane (the current owner) is completing pilot studies to route extracted groundwater through the Goodyear WWTP for treatment.
Universal Propulsion Co. (Site No. 10)	Goodrich Universal Propulsion, located near the intersection of Central Avenue and Happy Valley Road, manufactures solid propellant actuated devices, aircraft ejection seats and miscellaneous products related to the military and aerospace industries. In March, 2004, UPCO informed ADEQ of the discovery of perchlorate ranging from 43 to 130 ppb in their groundwater monitoring wells. Since March, UPCO and ADEQ have collected additional samples from more than 50 wells in the adjacent neighborhoods; none of these samples contained levels of perchlorate above the method reporting limit of 2 ppb. UPCO has entered into a consent order with ADEQ to investigate and remediate the perchlorate in the groundwater and soil.

Yuma Marine Corps Air Station (not on map)	The Yuma Marine Corps Air Station (YMCAS) occupies approximately 4800 acres in the city and county of Yuma. The station's primary function has been flight training for pilots on F-4 Phantom, A-4 Skyhawk and AV-8A Harrier aircraft. The YMCAS was placed on the National Priorities List (NPL) in 1990 and is known to be contaminated with solvents, petroleum hydrocarbons from jet fuel and miscellaneous industrial wastes such as asbestos, PCBs and pesticides/herbicides. Monitoring has confirmed perchlorate detections in groundwater at 4 ppb and in surface water at 5 ppb.
Yuma Proving Ground (Site Nos. 11, 12, 13)	The Yuma Proving Grounds (YPG) is located 32 miles northeast of Yuma, along the Colorado River and occupies approximately 870,000 acres in Yuma and La Paz Counties. Its recent mission is to conduct environmental testing of equipment and advanced technology related to aircraft armament systems, air delivery systems, and tank-automotive equipment. The YPG is not on the National Priorities List but is being co-managed by ADEQ and the Department of Defense under the Army's Installation Restoration Program. Known contaminants at the site include petroleum hydrocarbons, volatile organic compounds, metals and perchlorate. Monitoring conducted in April 1999 found perchlorate was detected in surface water at 5 ppb.

Conclusions of the Water Quality Assessment

Perchlorate is present in certain areas of the state but generally levels are well below Arizona's HBGL. Comparing the 2004 sampling results with earlier sampling efforts indicates that remedial actions at the source in Nevada have resulted in a slow but steady decline in concentrations in both surface water and groundwater along the Colorado River as well as in those areas using Colorado River water. Surface water concentrations at the Wilmer Pumping Plant, intake to the Central Arizona Project, continue to decrease over time. It is expected that these levels will continue to decline as perchlorate releases to Las Vegas Wash are reduced.

In 2003, Flow Science conducted perchlorate modeling for Metropolitan Water District to estimate how long it will take Colorado River perchlorate concentrations to reach target levels under various control strategies and hydrological conditions. The report assumed the 90% capture of all perchlorate sources to Las Vegas Wash and predicted perchlorate concentration levels at the Colorado River Aqueduct intake (in the same vicinity as the CAP intake at the Wilmer Pumping Plant) to reach 4 ppb by mid-2004 and 2 ppb by mid to late 2005. The average annual concentration in the river at this location is 4.8 ppb (4.5 ppb at Wilmer).

While concentrations are declining, the impacts of the drought and seasonal variations on perchlorate concentrations are unknown. Generally, the drought has resulted in less water entering Lake Mead and reservoirs in Arizona that receive Colorado River water. This has resulted in overall decreases in lake volumes. If the drought continues, perchlorate concentrations in Lake Mead and other reservoirs may not decline as much as expected and could possibly increase.

EVALUATION OF THE NATIONAL ACADEMY OF SCIENCES NATIONAL RESEARCH COUNCIL REPORT FROM THE *COMMITTEE TO ASSESS THE HEALTH IMPLICATIONS OF PERCHLORATE INGESTION*

Iodide is an essential component of thyroid hormones. In adults, the thyroid helps to regulate metabolism. At high doses, perchlorate can interfere with iodide uptake and disrupt how the thyroid functions. In children, the thyroid plays a major role in proper development, in addition to metabolism. Impairment of the thyroid function in expectant mothers may impact the fetus and newborns and result in effects including behavioral changes, delayed development and decreased learning capability. Chronic lowering of thyroid hormone levels due to high perchlorate exposure may also result in thyroid gland tumors.

In 2000, Dr. Ross Brechner of ADHS found differences in thyroid hormone levels among newborns in Yuma, which has low levels of perchlorate in its municipal water, and in Flagstaff, which has no detectable perchlorate in its municipal water. Dr. Brechner's work showed only an association between thyroid hormone levels and delivery of municipal water with perchlorate. The study did not demonstrate causation, and the report concluded that additional work was necessary to draw any conclusions. Other research, funded mostly by industry and the United States Department of Defense, suggests moderate doses of perchlorate might not affect healthy adults. A recent study by scientists at the Oregon Health and Science University, underwritten by the industry-sponsored Perchlorate Study Group, suggested that drinking water with perchlorate levels as high as 180ppb to 200 ppb are acceptable. Work by Texas Tech University scientists recently published in Environmental Science and Technology "unambiguously detected" perchlorate in levels of 1.7 – 6.4micrograms/liter in seven of seven supermarket milk samples bought randomly in Lubbock, Texas. This study suggests that in devising control and regulations strategies for perchlorate, total exposure must be considered. The study suggests further that total exposure cannot be estimated until better quantitative knowledge is acquired concerning the extent of occurrence of perchlorate in various types of food.

Currently there is no national water standard for perchlorate. In fact, many states have differing guidance levels. For example, California currently has a Public Health Goal of 4 ppb, Arizona has a Health Based Guidance Level of 14 ppb, Nevada has an interim clean up action level of 18 ppb, New Mexico has set a 1 ppb monitor and alert agencies level, New York has a 5 ppb notification level and an 18 ppb prepare for action level, and Texas has selected 5 ppb as its alert level.

The EPA has set an interim range of 4 to 18 ppb for perchlorate exposure. EPA issued a draft risk assessment January 18, 2002, proposing a drinking water value of 1 ppb. The EPA draft risk assessment presently is being reviewed by the National Academy of Sciences (NAS). NAS has convened a panel of experts that began review of the draft EPA risk assessment in June 2003, and expects to publish its review in late 2004 or early 2005.

Arizona has established a Health Based Guidance Level (HBGL) of 14 ppb for perchlorate in drinking water. HBGLs represent concentrations of contaminants in drinking water that are protective of public health during long-term exposure. They are not enforceable drinking water standards, but rather are advisory levels identifying the threshold where a contaminant can be present in drinking water and is considered safe for human consumption. Enforceable drinking water standards identify the threshold above which consumption of a contaminant in drinking water is considered unsafe.

ADHS uses health-based methodologies and assumptions that are consistent with risk assessment principles recommended by the EPA to develop HBGLs. The Arizona HBGL developed for perchlorate is specifically protective of childhood ingestion exposure. Exposure assumptions reflect childhood contact rates and body weight. The focus on children is protective of the higher daily intake rates by children and their lower body weight. The exposure duration was assumed to be 350 days/year for 6 years. Exposure doses are averaged over the period of exposure (6 years).

The perchlorate taskforce was charged with evaluating the Arizona perchlorate HBGL to determine if new data would merit a revision to the current 14 ppb level. The taskforce determined that the appropriate approach is to review first the findings of the NAS committee evaluating the EPA draft drinking water reference dose. When this information becomes available, the perchlorate taskforce will complete a review of the NAS report and determine if changes are necessary to the Arizona perchlorate HBGL.

EVALUATING THE EFFECT OF PERCHLORATE IN WATER TO ARIZONA AGRICULTURE

Agriculture is a critical sector of Arizona's economy. As such, reviewing the impact of perchlorate on agricultural food crops, irrigated with Colorado River waters was among the charges to the taskforce. Research into the effect of perchlorate on agricultural food crops is emerging quickly and is a primary area of interest among the research and public health community alike.

Dr. Charles Sanchez, a Research Scientist with the University of Arizona, Yuma Agricultural Center, has been leading research on this topic for several years, and the task force supports Dr. Sanchez's continued efforts. Currently published research has shown that only trace levels of perchlorate is present in lettuce that are irrigated with perchlorate contaminated Colorado River water.

Safety standards for perchlorate in water center on a widely accepted risk factor of a two liter per-day consumption rate. The dietary contribution of perchlorate from lettuce and other food products and the resulting health risk must account not only for perchlorate levels in those food products, but also the consumption rate of those food products. Recently published research reports by Dr. Sanchez have included exposure data for perchlorate in vegetables produced with Colorado River water. These data show the exposure to perchlorate, once converted to enable comparison to drinking water exposure, is below the 1 ppb level currently being proposed by EPA as the drinking water reference dose, currently under review by the National Academy of Sciences and appreciably below Arizona's HBGL of 14 ppb and California's Public Health Goal of 6 ppb. The task force will continue to monitor the work of Dr. Sanchez and others.

CONCLUSIONS AND RECOMMENDATIONS

Arizona's Colorado River water resources remain relatively unaffected by the significant perchlorate contamination at the Kerr McGee site that has moved into the Colorado River through Lake Mead. Current monitoring confirms perchlorate levels in the Colorado River main stem and in groundwater near the Colorado River are reducing in concentration. In the Central Arizona Project Canal and Lake Pleasant and at the San Xavier Pumping Plant in Tucson, perchlorate levels have been reduced to levels near the detection level of 2 ppb. Moreover, the significant use of Colorado River for direct and indirect recharge does not appear to have introduced perchlorate in detectable levels into central and southern Arizona's aquifers. Elevated levels of perchlorate have been found in water bodies at industrial sites in Arizona, however none of these water bodies are presently used for drinking water purposes.

Review of Arizona's Health Based Guidance Level of 14 ppb indicates that the Arizona risk assessment methodology used, focused on the ingestion of drinking water by children under the age of 6 years, remains protective of human health, absent new information. The National Academy of Sciences review of the EPA draft risk assessment of perchlorate, when published later this year will provide sufficient information for ADHS to determine if the HBGL for perchlorate should be revised.

Finally, review of the current research on the impact of perchlorate in food, performed by the University of Arizona's Dr. Charles Sanchez, suggests that the levels of perchlorate ingested by eating lettuce irrigated with Colorado River water is about 1 ppb, well below the Arizona HGBL of 14 ppb. The task force will continue to monitor research on this matter.

Recommendations

- Continue State monitoring of critical components of Arizona's water management strategy to gain a better understanding of fate and transport of perchlorate at underground storage facilities and in aquifers showing signs of impacts.
- Review the final National Academy of Sciences evaluation of the EPA study, when it is released to determine if Arizona should revise its HBGL for perchlorate.
- Continue State oversight of remediation work at industrial and military sites identified in this report.
- Continue to monitor research efforts on the effect of perchlorate in food and any related risks to public health.

SELECTED REFERENCES

Arizona Department of Environmental Quality, "Arizona Perchlorate Occurrence Study: Drinking Water Sources, Phase One"; Water Quality Division, OFR99-14, 1999

Arizona Department of Health Services, "Health Based Guidance Level for Perchlorate (CLO_4^-), Office of Environmental Health, May, 2000

Brechner, R., et al, "Ammonium Perchlorate Contamination of Colorado River Drinking Water is Associated with Abnormal Thyroid Function in Newborns", *Journal of Occupational and Environmental Medicine*, 2000; 42:777-782

Kirk, Andrea B., et al, "Perchlorate in Milk", *Environmental Science and Technology*, September 18, 2003

City of Phoenix Water Services Department, Supplemental Environmental Project #2: MTBE and Perchlorate Sampling Program, 1999-2000

Potts, Katie E.; Charles A. Sanchez; Robert I. Krieger; "Perchlorate Uptake, Accumulation, and Distribution in Lettuce Irrigated with Colorado River Water". Presentation at the 227th Academy of Chemical Scientists National Meeting, Anaheim, CA, March 28-April 1, 2004.

Sanchez, Charles; Robert I. Krieger, "Occurrence of Perchlorate in Vegetable Crops Produced in the Lower Colorado River Region". Presentation at the Office of Risk Assessment and Cost Benefit Analysis Risk Forum in July, 2004. Can be downloaded at: www.usda.gov/agency/oce/oracba/forum.htm

U.S. Environmental Protection Agency, "Perchlorate Monitoring Results: Henderson, NV to the Lower Colorado River, June 2004 Report", data complied by USEPA Region 9.

U.S. Environmental Protection Agency, "Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization (2002 External Review Draft)", Office of Research and Development, National Center for Environmental Assessment, Washington, DC, NCEA-1-0503, 2002

U.S. Food and Drug Administration, Office of Plant and Dairy Foods and Beverages, Center for Food Safety and Applied Nutrition website:

Perchlorate Questions and Answers-- regarding perchlorate in lettuce, milk, bottled water and other related issues. Can be downloaded at: www.cfsan.fda.gov/~dms/clo4qa.html

Exploratory Data on Perchlorate in Food – data on perchlorate in lettuce, bottled water and milk. Can be downloaded at: www.cfsan.fda.gov/~dms/clo4data.html

Appendix A

SAMPLING & ANALYSIS PLAN

Perchlorate Occurrence Study

Sampling and Analysis Plan

Anticipated Sampling Dates: May – June, 2004

Prepared by:
Hydrologic Support & Assessment Section
Water Quality Division
Arizona Department of Environmental Quality

Approved by ADEQ Project Lead	Date: ____________________
Approved by ADWR Project Lead	Date: ____________________
Reviewed by QA Unit	Date: ____________________
Approved	Date: ____________________

TABLE OF CONTENTS

1.0 Project Overview

This reconnaissance sampling effort will involve the collection of both surface water and groundwater samples from approximately 100 locations throughout Arizona and analyze them for presence and concentrations of perchlorate. The primary objective of the sampling effort is to determine whether perchlorate is found in surface and/or ground water supplies in the state. Samples will be collected from a broad range of locations including surface waters, canals, wells, and underground storage facilities, animal feeding operations as well as background locations in order to evaluate the levels and actual occurrence of perchlorate throughout the state. A number of different agencies have been collecting perchlorate data since the late 1990's for a variety of reasons. To the extent possible and providing the data is credible and scientifically defensible, existing data from other entities will be included in the summary report of perchlorate occurrences in Arizona.

1.1 Responsible Agencies

This is a joint sampling effort between the Arizona Departments of Environmental Quality (ADEQ) and Water Resources (ADWR). Staff from ADEQ's Hydrologic Support and Assessment Section will lead the sampling project with support and assistance from the Hydrology Division of ADWR. Staff from both agencies will coordinate with land owners prior collecting samples in order to obtain access and permission to sample. Potential land owners include the federal government, state agencies, municipalities, private land owners and tribes. The sampling teams will be responsible for collecting and delivering samples to the contract laboratory for analysis. The sampling will occur during the months of May through July of 2004 in order to obtain analytical results in time to provide a summary of perchlorate occurrence in the State for a report to the Governor in September, 2004.

1.2 Project Organization

Title/Responsibility	Name	
Project Manager (ADEQ)	Linda Taunt, Section Mgr	602.771.4416
Project Manager (ADWR)	Drew Swieczkowski, Section Mgr	602.417.2400 ext. 7308
Sample Coordinator	Steve Franchuk	602.771.4472
Field Team Leader	Susan Fitch – lakes, river sampling	602.771.4541
	Doug Towne – groundwater sampling	602.771.4412
	Angela Lucci – groundwater sampling	602.771.4551
	David Christiana – underground storage facilities	602.417.2400 ext. 7339
Laboratory Manager	Ken Baker Del Mar Laboratory Tom French Montgomery Watson Laboratory	480.785.0043 (primary) 480.778.1558 (secondary)
Data Managers	Marianne Gilbert (groundwater) Jennifer Hickman (lakes) Doug McCarty (surface water)	602.771.4563 602.771.4542 602.771.4471

1.3 Statement of the Specific Problem

Perchlorate is an oxidizing anion that occurs in ground and surface waters from the dissolution of ammonium-, potassium-, magnesium- or sodium- perchlorate salts. Perchlorate is very soluble and mobile in aqueous systems and because it degrades very slowly it can persist for many decades under typical ground and surface water conditions. Ammonium perchlorate is manufactured for use as an oxidizer component and primary ingredient in solid propellents for rockets and missiles. Perchlorate is also used in the manufacturing of matches, air bag inflators, and fireworks.

Perchlorate has been manufactured at two facilities near Henderson, NV -- Pacific Engineering & Production Company of Nevada and Kerr-McGee Chemical Corporation – from World War II to the present. Considerable amounts of process effluents have been discharged into unlined surface channels that conveyed the waste to unlined evaporation ponds. As a result of continuous percolation of perchlorate contaminated water into the underlying aquifer, the groundwater in the vicinity of the industrial complex has been contaminated. The groundwater contaminated with soluble ammonium perchlorate has been seeping into the Las Vegas Wash which drains into Lake Mead, and ultimately into the Colorado River as it flows through Hoover Dam. Detectable concentrations of perchlorate have been found from Lake Mead to Yuma. The contaminated seepage contained perchlorate at 100 mg/L (100,000 ppb); while in the wash, the concentrations varied from 10 – 750 ppb. Concentrations of 10-20 ppb have been detected in the water intakes for Las Vegas and at Hoover Dam (EPA, 1999). Both Arizona and California withdraw Colorado River water from Lake Havasu and deliver it inland for use in agriculture, municipal and industrial uses; as well as store it for future use in ADWR permitted underground storage facilities and groundwater savings facilities. Many communities along the river also withdraw water directly from the Colorado for domestic and agricultural uses. Concentrations in the Colorado River below Lake Mead to Yuma have ranged from results at the analytical test detection limit (usually 4 ppb) to 11 ppb.

Studies indicate that perchlorate disrupts iodine uptake in the thyroid gland, which regulates hormone function. Pregnant women and children are most vulnerable to the effects of perchlorate. In 2003, perchlorate was found in the outer leaves of leafy vegetables grown in the Yuma area (e.g., lettuce). A study in Texas revealed concentrations of perchlorate in milk, suggesting that perchlorate may be taken up in feed used for dairy animals.

A maximum contaminant level (MCL) has not yet been established by the U.S. Environmental Protection Agency. Arizona has established a Health-based Guidance Level of 14 ppb; California has recently adopted a Public Heath Goal of 6 ppb and Nevada has set its level at 18 ppb.

2.0 *Site Identification*

A wide variety of sampling sites have been chosen throughout the State. The sites include some known to have perchlorate contamination but predominantly the sites have been selected to evaluate the levels and occurrence of perchlorate in Arizona's water resources. The characterization sites include: lakes; domestic water supply wells; agricultural wells; municipal drinking water supplies; concentrated animal feeding operations (CAFOs); ADWR permitted underground storage facilities & groundwater savings facilities; the Central Arizona Project (CAP) canal; as well as sites thought to be background (e.g., contain no human-caused or natural sources of perchlorate).

Figure 2.1 presents a map of the proposed sampling locations. Some of the proposed sampling sites are ongoing sampling locations that are currently being monitored by entities including the EPA, Nevada Department of Environmental Protection, Metropolitan Water Company (of California) and the Central Arizona Water Conservation District, which operates the CAP system. Other sites are new locations for which no data is currently known and have been selected as possible sampling locations by ADEQ and ADWR to characterize certain areas deemed susceptible to perchlorate contamination. Some areas show multiple proposed sampling locations. Final locations will be chosen based on several factors determined during field reconnaissance (e.g., physical accessibility, equipment restrictions) and will be shown in the Perchlorate Task Force Summary Report.

The list of the proposed sampling sites along with their latitude and longitude are shown in *Table 2.1* and correspond to the numbers shown in *Figure 2.1*. *Table 2.1* contains over 180 sites – some are existing sites with data and some are groupings from which final sites will be selected. Latitude and longitude for some of the sites are approximate. Sampling teams will record the exact locations using a handheld Garmin GPS during the sampling visit. Approximately 100 sites will be sampled during this project.

Figure 2.1 – Proposed Sampling Locations

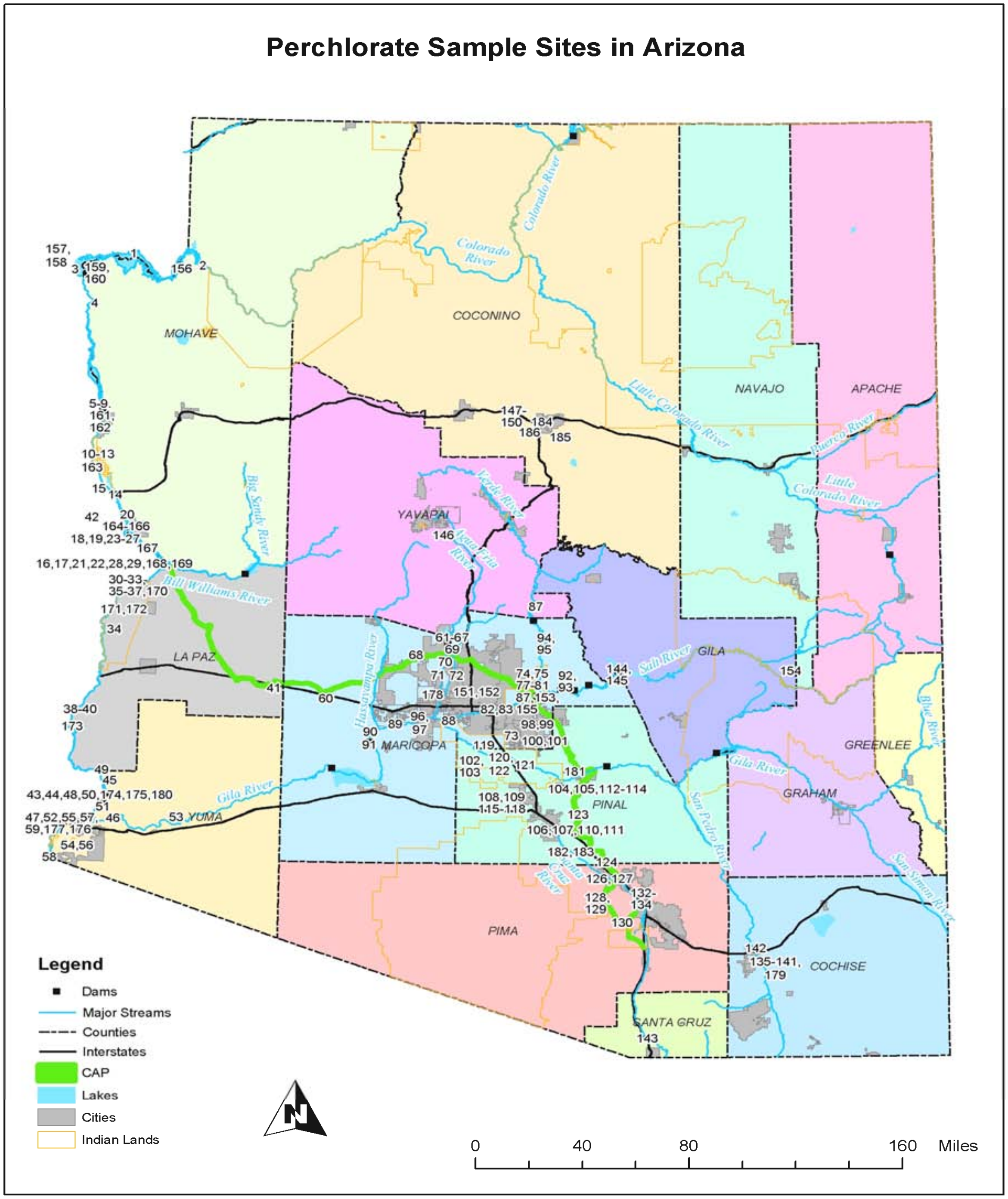

Table 2.1 – List of proposed sampling sites

Map Num	sitename	site_id	Collection Agency	New or existing	lat_dd	long_dd	County	Remarks
1	Virgin River above Lake Mead		CLP		36.178330	114.411390	Mohave	
2	Lake Mead at Pearce Ferry		CLP		36.116110	113.946940	Mohave	
3	Lake Mead		NDEP	E	36.069170	114.801100	Mohave	At Saddle Island.
4	Willow Beach – Mainstem Colorado River		NDEP	E	35.870560	114.661390	Mohave	
5	Bullhead City Well(s)	From 5 – 13 --	GWMU		35.147780	114.568330	Mohave	General location.
6	City of Bullhead City	need 6 wells	GWMU		35.117780	114.582220	Mohave	
7	Arizona-American		GWMU		35.103890	114.612500	Mohave	
8	Arizona-American		GWMU		35.146110	114.562500	Mohave	
9	Mohave High School		GWMU		35.105000	114.601390	Mohave	
10	Fort Mojave Indian Reservation Well(s)		GWMU		34.955000	114.625560	Mohave	General location.
11	Mohave Farms/CB Sherrill		GWMU		34.892780	114.613300	Mohave	
12	Mohave Farms/CB Sherrill		GWMU		34.890560	114.611390	Mohave	
13	Mohave Farms/CB Sherrill		GWMU		34.963330	114.617780	Mohave	
14	Colorado River at Topock		CLP		34.714720	114.485280	Mohave	At river gage.
15	Topock Marsh		CLP		34.836110	114.584170	Mohave	At inlet.
16	Lake Havasu – CMHAV-A		CLP		34.297780	114.138060	Mohave	Dam Location
17	Lake Havasu – CMHAV-A		CLP		34.297780	114.138060	Mohave	" " If stratified
18	Lake Havasu – CMHAV-B		CLP		34.451670	114.335560	Mohave	Outside of Thompson Bay
19	Lake Havasu – CMHAV-B		CLP		34.451670	114.335560	Mohave	" " If stratified
20	Lake Havasu – CMHAV-CRA		CLP		34.541940	114.386940	Mohave	Colorado River Inlet
21	Lake Havasu – CMHAV-PP		CLP		34.291390	114.108060	Mohave	Near Pumping Plant
22	Lake Havasu – CMHAV-BW		CLP		34.298890	114.099720	Mohave	Bill Williams Inlet
23	Lake Havasu Well #15		GWMU	E	34.505556	114.359444	Mohave	General location.
24	Lake Havasu Wells #16		GWMU	E	34.464722	114.337500	Mohave	General location
25	LHC Island ADEQ 51343 (MW-6)		GWMU		34.463890	114.353610	Mohave	
26	North LHC ADEQ 51348 (MW-11)		GWMU		34.484170	114.353890	Mohave	
27	South LHC ADEQ 51350 (MW-10)		GWMU		34.466390	114.336940	Mohave	

Table 2.1 – List of proposed sampling sites

Map Num	sitename	site_id	Collection Agency	New or existing	lat_dd	long_dd	County	Remarks
	LHC abv McCullough plant		GWMU					Abv McCullough plant
	LHC blw McCullough plant		GWMU					Blw McCullough plant
28	Central Arizona Project (CAP) Diversion at Wilmer (Havasu) Pumping Plant		CAP	E	34.288890	114.110280	La Paz	
29	Bill Williams above Lake Havasu		GWMU		34.254654	114.009227	La Paz	At Mineral Wash
30	Parker Well(s)	From 30-36	GWMU		34.150560	114.289170	La Paz	
31	Town of Parker Well #7	need 4 wells	GWMU		34.148060	114.292220	La Paz	
32	Town of Parker Well #6		GWMU		34.144720	114.284170	La Paz	
33	USBIA Well #4		GWMU		34.115830	114.311390	La Paz	
34	USBIA Well #2		GWMU		33.897780	114.446390	La Paz	
35	Town of Parker		GWMU		34.155830	114.283330	La Paz	
36	Town of Parker		GWMU		34.148330	114.289440	La Paz	
37	Colorado River Indian Reservation Diversion at Headgate Rock Dam		CLP		34.167780	114.275830	La Paz	At CRIT main canal.
38	LC Bishop	From 38-40	GWMU		33.400280	114.640560	La Paz	
39	LC Bishop	Need 2 wells	GWMU		33.378610	114.653610	La Paz	
40	Cibola Irrigation District		GWMU		33.387500	114.688060	La Paz	
41	Vidler Water Company UG-2		DWR	E	33.565583	113.395444	La Paz	
42	CAP Pumping Plant - Little Harquahala		DWR		34.603610	114.620560	La Paz	
43	Colorado River at Imperial Dam		CLP		32.883060	114.464170	Yuma	
44	Gila Main Canal – downstream of Imperial Dam		CLP		32.876110	114.455000	Yuma	
45	Martinez Lake CMMAR-A		CLP		32.981110	114.476670	Yuma	General location.
46	Wellton and Mohawk Canals near Wellton		GWMU		32.742500	114.433330	Yuma	At gage near Gila Main Canal.
47	City of Yuma		GWMU	E	32.725280	114.624440	Yuma	General location.

Table 2.1 – List of proposed sampling sites

Map Num	sitename	site_id	Collection Agency	New or existing	lat_dd	long_dd	County	Remarks
48	Yuma Proving Ground Well(s)	From 48-50	GWMU		32.861670	114.441110	Yuma	At headquarters.
49	US Fish and Wildlife	Need 2 wells	GWMU		32.998060	114.489440	Yuma	
50	Yuma Proving Grounds		GWMU		32.860280	114.438060	Yuma	
51	Mittry Lake CMMIT-A		CLP		32.820560	114.476670	Yuma	General location.
52	Yuma Area Wells	From 52 – 57	GWMU		32.710280	114.551390	Yuma	At Drainage Channel #1.
53	ADEQ 58136 MW-22	Need 4 wells	GWMU		32.755000	114.004440	Yuma	
54	ADEQ 58046 MW-24		GWMU		32.581670	114.715280	Yuma	
55	ADEQ 58139 MW-30		GWMU		32.695280	114.529440	Yuma	
56	ADEQ 57534 MW-12		GWMU		32.570830	114.709170	Yuma	
57	ADEQ 56259 MW-3		GWMU		32.705830	114.598060	Yuma	
58	Main Outlet Drain near San Luis		GWMU		32.497500	114.785000	Yuma	
59	Colorado River at Morelos Dam		GWMU		32.705000	114.725000	Yuma	At Highway 95.
60	Harquahala Valley		DWR		33.506670	113.055280	Maricopa	
61	Lake Pleasant MGPLE-A		CLP	E	33.848870	112.270130	Maricopa	Dam Location
62	Lake Pleasant towers @ dam		COP	E	33.844722	112.271389	Maricopa	Towers at the dam
63	Lake Pleasant MGPLE-B		CLP	E	33.905410	112.245650	Maricopa	river input
64	Lake Pleasant MGPLE-C		CLP	E	33.891630	112.276440	Maricopa	mid-lake
65	CAP Canal		CLP	E	33.780830	112.293560	Maricopa	CAP1
66	CAP Canal		CLP	E	33.779380	112.246720	Maricopa	CAP2
67	Lake Pleasant upstream		COP	E	33.781556	112.286167	Maricopa	0.5 mi W 99th Ave
68	Lake Pleasant downstream		COP	E	33.779444	112.474444	Maricopa	99th Ave & CAP
69	Agua Fria Managed/Constructed		DWR		33.730560	112.290000	Maricopa	CAP MW-3
70	Agua Fria Managed/Constructed		DWR		33.781390	112.279440	Maricopa	CAP MW-4
71	City of Peoria MW-2		DWR		33.660833	112.299720	Maricopa	
72	City of Glendale MW-3		DWR		33.656667	112.234720	Maricopa	
73	City of Chandler Obs -1		DWR		33.269722	111.827780	Maricopa	
74	Salt River		COP	E	38.518067	111.684440	Maricopa	Blue Pt bridge
75	Verde River		COP	E	33.580804	111.684440	Maricopa	Bush Hwy bridge
76	Salt River Project - Arizona Canal - downstream of Granite Reef Dam		DWR		33.515830	33.515830	Maricopa	
77	Salt River Project - Southern Canal - downstream of Granite Reef Dam		DWR		33.511940	111.695000	Maricopa	

Table 2.1 – List of proposed sampling sites

Map Num	sitename	site_id	Collection Agency	New or existing	lat_dd	long_dd	County	Remarks
78	Granite Reef Underground Storage Project (GRUSP)		DWR		33.483330	111.741670	Maricopa	RCMWGR1
79	GRUSP		DWR		33.492780	111.753330	Maricopa	RCMWGR2
80	CAP Canal Downstream of Salt-Gila Pumping Plant.		DWR		33.481390	111.681670	Maricopa	Nr Spook Hill
81	CAP Canal @ McKellips Bridge		COP	E	33.451327	111.671321	Maricopa	E. of Power Rd
82	Tempe Town Lake MGTTL-A		CLP		33.433610	111.947780	Maricopa	West Dam Location
83	Papago Park Lakes MGPAP-A		CLP		33.454440	111.944720	Maricopa	General location.
84	Unidynamics Phoenix Inc. at the Goodyear Airport		WPD	E			Maricopa	
85	Universal Propulsion (UPCO)		WPD	E			Maricopa	
86	Talley/TRW Industries		WPD	E			Maricopa	
87	City of Mesa Red Mountain Lake		CLP		33.434720	111.668610	Maricopa	General location.
88	Gila River below 91st Avenue Treatment Plant		SWMU		33.382780	112.257780	Maricopa	
89	ADEQ 56869 MW-3		GWMU		33.357220	112.641670	Maricopa	
90	ADEQ 56875 MW-8		GWMU		33.278890	112.780280	Maricopa	
91	Gila River at Gillespie Dam		SWMU		33.228890	112.768330	Maricopa	
92	Saguaro Lake SRSAG-A		CLP		33.568060	111.536110	Maricopa	Dam Location
93	Saguaro Lake SRSAG-A		CLP		33.568060	111.536110	Maricopa	" " If stratified
94	Bartlett Lake VRBAR-A		CLP		33.817780	111.627500	Maricopa	Dam Location
95	Bartlett Lake VRBAR-A		CLP		33.817780	111.627500	Maricopa	" " If stratified
96	SW Calf Ranch		DWR		33.374170	112.463890	Maricopa	
97	SW Calf Ranch		DWR		33.374720	112.463060	Maricopa	Alternate site
98	Arizona Dairy Co		DWR		33.349720	111.681390	Maricopa	
99	Arizona Dairy Co		DWR		33.358330	111.684170	Maricopa	Alternate site
100	DeJong Dairy		DWR		33.260280	111.760000	Maricopa	
101	DeJong Dairy		DWR		33.262220	111.758060	Maricopa	Alternate site
102	Hogenes Dairy		DWR		33.070556	112.065000	Pinal	
103	Hogenes Dairy alt		DWR		33.070000	112.065000	Pinal	Alternate site

Table 2.1 – List of proposed sampling sites

Map Num	sitename	site_id	Collection Agency	New or existing	lat_dd	long_dd	County	Remarks
104	San Carlos Irrigation District	From 104 – 122	DWR		32.977500	111.437780	Pinal	Elo-N-1
105	City of Coolidge	Need 6 wells	DWR		32.972780	111.515830	Pinal	Elo-N-2
106	AZ State Land Department		DWR		32.720000	111.472500	Pinal	Elo-S-1
107	AZ State Land Department		DWR		32.690830	111.498330	Pinal	Elo-S-2
108	AZ State Land Department		DWR		32.850560	111.919720	Pinal	M-S-1
109	AZ State Land Department		DWR		32.886110	111.937500	Pinal	M-S-2
110	AZ State Land Department		DWR		32.720000	111.467500	Pinal	Elo-S
111	AZ State Land Department		DWR		32.734170	111.496940	Pinal	Elo-S
112	San Carlos Irrigation District		DWR		32.991390	111.482220	Pinal	Elo-N
113	San Carlos Irrigation District		DWR		32.971670	111.488610	Pinal	Elo-N
114	San Carlos Irrigation District		DWR		32.959440	111.488610	Pinal	Elo-N
115	AZ State Land Department		DWR		32.857500	111.911390	Pinal	M-S
116	AZ State Land Department		DWR		32.850560	111.913330	Pinal	M-S
117	AZ State Land Department		DWR		32.850830	111.902500	Pinal	M-S
118	AZ State Land Department		DWR		32.850560	111.894440	Pinal	M-S
119	GRIC Well		DWR		33.235560	112.029440	Pinal	UM89
120	GRIC Well		DWR		33.128610	111.900280	Pinal	No.61
121	GRIC Well		DWR		33.117500	111.760000	Pinal	No SW29
122	GRIC Well		DWR		33.124720	111.942220	Pinal	No. 131
123	CAP Pumping Plant - Brady		DWR		32.816940	111.416110	Pinal	
124	CAP Canal at Pima County Line		DWR		32.500830	111.232500	Pinal	
125	Aerodyne Corporation on the Gila River Indian Reservation		GRIC	E			Pinal	
126	Avra Valley CAP		DWR		32.416670	111.214720	Pima	AVMW-01
127	Avra Valley CAP		DWR		32.429170	111.214720	Pima	SC-09
128	CAVSARP		DWR		32.250830	111.257220	Pima	WR314A

Table 2.1 – List of proposed sampling sites

Map Num	sitename	site_id	Collection Agency	New or existing	lat_dd	long_dd	County	Remarks
129	CAVSARP		DWR		32.256390	111.257220	Pima	WR262A
130	CAP Pumping Plant - San Xavier		DWR		32.161670	111.131110	Pima	
131	Tucson Water Treatment Facility		DWR				Pima	
132	Roger Road Wastewater Treatment Plant		SWMU		32.281390	111.025560	Pima	
133	Sweetwater USF		DWR		32.278890	111.029440	Pima	WR-068A
134	Sweetwater USF		DWR		32.273330	111.027500	Pima	WR-199A
135	Apache Nitrogen Products		Hargis	E	31.907354	110.249008	Cochise	D(17-20)36ddd
136	Apache Nitrogen Products		Hargis	E	31.905301	110.247877	Cochise	D(18-20)01aad
137	Apache Nitrogen Products		Hargis	E	31.877946	110.236034	Cochise	MW-15
138	Apache Nitrogen Products		Hargis	E	31.902835	110.241359	Cochise	P-03
139	Apache Nitrogen Products		Hargis	E	31.879336	110.222056	Cochise	SW-03
140	Apache Nitrogen Products		Hargis	E	31.897079	110.241029	Cochise	SW-12
141	San Pedro River near St. David		SWMU		31.905278	110.245556	Cochise	At Hwy 80 bridge crossing
142	San Pedro River near Benson		SWMU		31.968330	110.278330	Cochise	At Interstate 10.
143	Santa Cruz downstream of the Nogales International Wastewater Treatment Plant		SWMU		31.458610	110.970000	Santa Cruz	At railroad crossing.
144	Roosevelt Lake SRROO-A		CLP		33.674170	111.156110	Gila	Dam Location
145	Roosevelt Lake SRROO-A		CLP		33.674170	111.156110	Gila	" " If stratified
146	Fain Lake MGFAI-A		CLP		34.508330	112.308060	Yavapai	Dam Location
147	Navajo Army Depot		WPD	E	35.169679	111.857981	Coconino	
148	Navajo Army Depot		WPD	E	35.171099	111.857234	Coconino	
149	Navajo Army Depot		WPD	E	35.170938	111.857233	Coconino	
150	Navajo Army Depot	gw well	ASUA	E	35.219149	111.833729	Coconino	
151	Squaw Peak WTP	raw water	COP	E	33.526322	112.032092	Maricopa	
152	Deer Valley WTP	raw water	COP	E	33.569966	112.124025	Maricopa	
153	Val Vista WTP	raw water	COP	E	33.466721	111.760014	Maricopa	

Table 2.1 – List of proposed sampling sites

Map Num	sitename	site_id	Collection Agency	New or existing	lat_dd	long_dd	County	Remarks
154	Union Hills WTP	raw water	COP	E	33.686848	110.036503	Maricopa	
155	Verde WTP	raw water	COP	E	33.544988	111.668011	Maricopa	
156	Lake Mead S. Cove	lake offshore	ASUA	E	36.092245	114.088922	Nevada	
157	Las Vegas Bay	surface	ASUA	E	36.130017	114.869564	Nevada	
158	Las Vegas Bay	bottom	ASUA	E	36.130017	114.869564	Nevada	
159	Lake Mead - Kingman Wash surface	surface	ASUA	E	36.035573	114.707842	Mohave	
160	Lake Mead - Kingman Wash surface	bottom	ASUA	E	36.035573	114.707842	Mohave	
161	Lake Mohave Katherine Landing	surface	ASUA	E	35.215363	114.572914	Mohave	
162	Lake Mohave Katherine Landing	bottom	ASUA	E	35.215363	114.572914	Mohave	
163	FMTUA	tribal HQ well	ASUA	E	34.918671	114.630358	Mohave	
164	Chemehuevi IR	river chan top	ASUA	E	34.548098	114.394297	Mohave	
165	Chemehuevi IR	river chan bot	ASUA	E	34.548098	114.394297	Mohave	
166	Chemehuevi IR	irrigation	ASUA	E	34.521549	114.394722	Mohave	
167	Chemehuevi IR	Havasu Palms well	ASUA	E	34.400661	114.277069	Mohave	
168	LA intake Lake Havasu	in lake b4 intake	ASUA	E	34.316900	114.156706	California	
169	BW NWR	east of Colorado Rv	ASUA	E	34.298869	114.087800	Mohave	
170	CRIT	Big River well	ASUA	E	34.120602	114.377814	La Paz	BW river east of Colorado confluence
171	CRIT	main irrig canal	ASUA	E	34.013241	114.389406	La Paz	
172	CRIT	Colorado Rv mainstem	ASUA	E	34.042498	114.434383	La Paz	Main canal at Mohave Rd
173	Cibola NWR	Colo Rv shoreline	ASUA	E	33.302886	114.676847	La Paz	Agnes Wilson bridge
174	S. of Imperial Dam	All American canal	ASUA	E	32.872826	114.478386	Yuma	
175	Yuma Proving Grounds	Colo Rv shoreline	ASUA	E	32.850470	114.441981	Yuma	
176	N. Cocopah IR	gw well	ASUA	E	32.738487	114.692158	Yuma	
177	N. Cocopah IR	Colo Rv shoreline	ASUA	E	32.739929	114.692175	Yuma	RV Park
178	Luke AFB	gw well	ASUA	E	33.538974	112.364019	Maricopa	
179	St. David	San Pedro	ASUA	E	31.905449	110.245828	Cochise	
180	GilRiver	Florence	ASUA	E	32.872826	114.478386	Pinal	

Table 2.1 – List of proposed sampling sites

Map Num	sitename	site_id	Collection Agency	New or existing	lat_dd	long_dd	County	Remarks
181	CAP crossing St Hwy 79	Florence	ASUA	E	33.078519	111.373386	Pinal	AZ Army National Guard Res
182	Red Rock	CAIDD	ASUA	E	32.588349	111.414036	Pinal	over bridge railing
183	Avra Valley recharge	CAP recharge	ASUA	E	32.588349	111.402544	Pima	CAP inlet
184	Lake Mary WTP	gw well	ASUA	E	35.150106	111.650700	Coconino	
185	Lake Mary WTP	raw water	ASUA	E	35.109085	111.585589	Coconino	
186	Lake Mary WTP	raw water	ASUA	E	35.159163	111.715108	Coconino	

Collection Agencies:

- ASUA – Arizona Small Utilities Association
- CAP – Central Arizona Project
- CLP – Clean Lakes Program (ADEQ)
- COP – City of Phoenix
- DWR – Arizona Department of Water Resources
- GRIC – Gila River Indian Community
- GWMU – Groundwater Monitoring Unit (ADEQ)
- Hargis – Hargis & Associates (contractor for Apache Nitrogen)
- NDEP – Nevada Department of Environmental Protection
- SWMU – Surface Water Monitoring Unit (ADEQ)
- WPD – Waste Programs Division (ADEQ)

3.0 Project Data Quality Objectives

The quality assurance objective of this study is to ensure that environmental sampling and analysis efforts produce credible and scientifically sound data. These samples are not for compliance purposes as there is no enforceable water quality standard for perchlorate. The data quality objectives (DQOs) are both qualitative and quantitative statements. The development of DQOs is a systematic and iterative process to evaluate and identify the data needed for decision-making.

3.1 Project Task/Sampling Objectives

Water quality data from this sampling effort will be used along with other existing data to characterize the presence of perchlorate in Arizona. A summary of occurrence will be provided in the final report issued by the Perchlorate Task Force in the fall, 2004. The Task Force is a multi-agency task force to assess the risk of perchlorate to Arizonans. The group has formed several subgroups each charged with different aspects of the issue including: determining what levels of perchlorate exist throughout the State and the likely source; the health-related problems associated with the chemical; the impact of perchlorate on the agriculture and food crop industry and how to disseminate the information to the public, especially to sensitive or vulnerable populations.

3.2 Data Quality Objectives

The quality objective of this study is to ensure that environmental sampling and analysis efforts produce credible and scientifically sound data in accordance with the sampling objectives for this event. This will be accomplished by documenting the precision of the analyses and in verifying the production of accurate results. The goals will be obtained by using the following methods of quality assurance:

3.2.1 Precision

Overall precision will be determined through field duplicate and split analyses. Approximately ten percent of the samples will be field duplicates and/or split samples. Given that approximately 100 samples will be collected and analyzed, approximately 10 field duplicates and splits will be required. The precision goal for this project shall be results within 10% of the average of the two values reported. Duplicates will be analyzed by Del Mar Laboratory; splits samples will be sent to Montgomery Watson Laboratory.

3.2.2 Accuracy

Accuracy will be determined by the analyses of spiked samples. An accuracy assessment will be conducted at least once per matrix type (e.g., groundwater, lake water, surface water). Recovery will be expected to be +/-10% of actual spiked concentration. If the accuracy deviates from this goal, the source of the deviation will be researched and documented.

[Note: Montgomery Watson Laboratories will prepare the spiked samples at concentrations of 4, 8 and 40 ug/L for analysis by Del Mar Laboratories].

3.2.3 Comparability

For this project, comparability will be defined as the degree to which analyses from previous sampling efforts, at existing sites, corroborate the results obtained from this event. Where results are not comparable, standard operating procedures for respective sampling events will be reviewed and compared. Differences in both the sampling methodologies and results will be documented. Due to the remedial efforts in Nevada, concentrations of perchlorate are slowly declining on the River. However the intensive monitoring at key locations provides a good record of the gradual reduction and will assist in assessing comparability of results from this sampling to earlier sampling efforts.

3.2.4 Representativeness

This is the degree to which a group of samples is indicative of the population being studied at a particular site. Representativeness is a qualitative factor which is affected by appropriate sampling and laboratory protocols and will be achieved by using the most environmentally conservative approach to sampling. For the objectives of this study, representative samples will be collected using grab samples and proper sampling protocols.

Excellent quality analytical data, representativeness and comparability are expected. Experienced field monitoring staff from the Hydrologic Support and Assessment Section in Water Quality Division at ADEQ and the Hydrology Division at ADWR will conduct the sampling. Del Mar Analytical Laboratory will perform the analyses. Montgomery Watson will provide QA/QC analysis on split samples and provide spikes. Both laboratories are certified in the State of Arizona

3.3 Data Review, Validation and Reporting

3.3.1 Data review

Data received from the laboratory will be reviewed by the project leads according to the guidelines presented in the Data Reduction and Reporting (section 7.10) and Data Validation, Assessment, and Corrective Action (section 7.11) of the ADEQ Quality Assurance Project Plan (QAPP) to determine whether internal quality control guidelines are met. The following minimum criteria must be met for the data to be acceptable for unqualified use by all parties involved in this study.

3.3.1.1 Split samples: Precision from the split samples submitted to a second laboratory shall be results within 10% of the average of the two values reported. These criteria will not apply if values are below the practical quantification limit.

3.3.1.2 Duplicate samples: Precision from the field duplicate samples submitted to the same laboratory shall be results within 10% of the average of the two values reported. These criteria will not apply if values are below the practical quantification limit.

3.3.1.3 *Trip blanks and field equipment blanks:* The concentration levels of any contaminants found in blank analyses will not be used to correct sample analytical results. If blank contamination is low-level compared to sample results, the sample results may still be meaningful. If contamination is present in blanks but not in the samples, the sample results also may be acceptable.

3.3.2 Analytical data management

Information pertinent to analytical results will follow EPA recommendations for data collection and management. A field notebook will contain hard contact persons, phone numbers, specific sample site locations, and field data relevant to sample collection. Samples will be assigned a unique ID number corresponding to each location. Chain-of-custody (COC) forms will be used to track sample transportation to the lab. Perchlorate results generated by the lab will be reviewed to verify concentrations corresponding to each unique ID number with COCs.

3.3.3 Reporting

Analytical data generated in this project will be provided to ADEQ and ADWR by the contract laboratories in both hard copy and electronic format. The data will be reviewed and validated by ADEQ and/or ADWR. All water quality data will be stored in the appropriate ADEQ database (e.g., surface water, groundwater). Any data generated through the use of State of Arizona funds or personnel must be subject to public data release and will be available for use by ADEQ and ADWR.

3.3.4 Assessment Oversight

Quality Assurance for this sampling project will be performed by the project leads in accordance with ADEQ Quality Assurance Program Plans and this Sampling and Analysis Plan.

4.0 Rationale for Analysis

4.1 Sampling Design

Proposed sampling locations have been selected based on a number of facts: (1) those areas thought to be isolated from any factors associated with perchlorate (e.g., "background sites"), (2) known past analysis indicating elevated perchlorate levels (e.g., UPCO, Apache Nitrogen, Yuma Proving Ground), (3) areas susceptible to perchlorate contamination (e.g., surface waters receiving Colorado River water, wells along the river, CAP canals and pumping plants, underground storage facilities storing CAP water, agricultural areas using CAP water, concentrated animal feeding operations).

4.2 Analyte of Concern

Perchlorate is the analyte of concern and the only analyte to be analyzed. It is anticipated that a wide range of concentrations will be found. Background values are typically below 2 ppb and this is the minimum reporting limit for the modified EPA Method 314. Some contaminated locations may have concentrations exceeding 700 ppb. The data will aid in determining overall presence and concentrations of the contaminant in Arizona.

The existing knowledge on the toxicological and health effects of perchlorate is very limited. The most predominant health risk is the explosive and flammable tendency – primarily during manufacturing.

Exposure to perchlorate at high concentrations is considered to be irritant to skin and mucous membranes (Prager, 1997). However, the health and toxicological effects of long-term exposure of perchlorate at low concentrations are poorly understood. Existing data show its potential to affect thyroidal hormone production; however there are no strong supporting data to evaluate the dose-response for the effect on the thyroid, developing fetuses, and other target tissues (EPA, 2000). The only available human health studies are the clinical reports from the patients treated for Grave's disease. The patients who were administered potassium perchlorate to treat excessive thyroidal activity developed skin rashes, sore throat, gastrointestinal irritation and showed hematological effects.

5.0 Request for Analysis

EPA Method 314 Ion Chromatography, Revision 1 (November 1999) is the current approved method for perchlorate in drinking water. In this method, perchlorate is separated and measured, using a system comprised of an ion chromatographic pump, sample injection valve, guard column, analytical column, suppressor device, and conductivity detector. This method recommends an ion chromatography (IC) column and analytical conditions which were determined to be the most effective for the widest array of sample matrices. Recent modifications to the method have reduced detection limits from 4 ppb to a range of less than 1 ppb. Method Detection Limits (MDLs) for perchlorate are 0.5 µg/L for water and 2 µg/Kg for soil samples. These MDL values place the Minimum Reporting Limits (MRLs) for water at 2.00 µg/L.

6.0 Field Methods and Procedures

6.1 Field Equipment & Calibration

6.1.1 Equipment

All equipment will be supplied by ADEQ or ADWR. For surface water sampling, other than access to the sampling locations (either driving, hiking or by boat), the only equipment needed are: the sample container and a global positioning system (GPS) unit. For groundwater sampling, because the well must stabilize before the sample is taken, a multiparameter probe (e.g., Hydrolab, YSI) and some attendant equipment will be needed as well as the sample container and GPS unit. Basic field parameters (e.g., temperature, pH, specific conductivity (EC)) will be taken at each site by all sampling teams.

The contract laboratory will provide, for each sampling site:

- 1 liter polyethylene bottles
- chain of custody forms

6.1.2 Calibration of Field Equipment

Field equipment will be calibrated according to manufacturer's specifications. Equipment checkout and calibration activities will occur prior to and upon return from each sampling trip and will be documented in the field notebook. Any major discrepancy between two consecutive readings of the parameters: temperature, pH and E.C. measured in the field will be resolved by repeating the field measurement.

6.2 Sample Collection

Collection of the samples is relatively straightforward. Perchlorate in water is fairly inert and not in gas or volatile form. Samples will not be filtered or preserved in the field.

6.2.1 Groundwater

Most of the groundwater samples will be collected from wells that are equipped with a dedicated pump. Wells will be purged a minimum of three casing volumes of water prior to collecting a sample. Field parameters (pH, temperature and EC) will be measured during purging until they stabilize. Stabilization is defined as two successive measurements with a less than a 10% difference between the two readings. All purging data will be recorded in the field notebook. One liter grab samples will be collected from each groundwater well. The standard operating protocols (SOP) for groundwater sampling are provided as Appendix A.

For any wells requiring the use of a portable submersible pump, additional equipment such as bailers and depth sounders will be needed and will be decontaminated as necessary. The pump will first be placed in a 50 gallon trash container with a mixture of tap water and Alconox. A total of 100 gallons of this solution will be pumped through the equipment. Next the pump will be placed in a 50-gallon trash container and will pump a total of 100 gallons of tap water to rinse.

The outside of the pump and hose will be decontaminated with a hot water high-pressure rinse. Any other reusable sampling equipment, such as transfer vessels, Hydrolabs, sounders, water level indicators, meters, and bailers, will be tripled rinsed in deionized water.

6.2.2 Surface Water and Lake Sampling

No specialized equipment will be necessary to sample perchlorate in surface water or from lakes. The sample container must be properly rinsed prior to sample collection and then the 1-liter sample is taken. The SOPs for sampling non-preserved constituents for both ambient lake sampling (Appendix B) and surface water (Appendix C) are provided as appendices. Because lake sampling requires use of a boat, special safety precautions are needed and documented in the Section 11: Field Heath and Safety.

6.3 Quality Control Samples

Covered under section 10 of this Sampling plan.

7.0 Sample Container, Preservation, Storage

7.1 Sample containers

All water samples will be collected in bottles and delivered to the contract laboratory not later than 14 days from date of sampling. Del Mar Laboratory will supply the pre-cleaned and certified 1-liter, polyethylene sample bottles to ADEQ.

7.2 Preservation

Samples do not require preservation and have a 28 day holding time per the EPA Method 314. Samples will be placed in ice immediately after sample collection. The following information will be recorded on the label: sample number; date of collection, time of collection, analysis requested, and sampler.

7.3 Grab Samples

Temperature, pH and specific conductivity (EC) will be measured at the time of sample collection. Where applicable, duplicate and split samples will be collected by filling the bottles for each analysis simultaneously.

Grab samples will be stored in portable ice chests and cooled to 4 degrees centigrade with ice immediately after sample collection and compositing until transported to the contract laboratory, generally within 24-48 hours of sampling. The following sampling packaging procedure will be followed to ensure that samples are intact when they arrive at the laboratory:

1. Place the bottles in the appropriate ice chest. Loose ice must not be poured into the cooler.
2. Affix the chain of custody form and other sample paperwork with the ice chest for surrender to the laboratory.

Field personnel will hand deliver the samples to the laboratory as soon as practicable after sample collection. If samples need to be stored overnight, they will be stored in an indoor area under observation or securely locked at all times.

8.0 Disposal and Equipment Decontamination

To prevent contamination between samples, disposable items such as bailers or nitrile gloves will be disposed of in a trash receptacle. These wastes are not considered hazardous and can be sent to a municipal landfill. Any disposable equipment that are to be disposed of which can still be reused will be rendered inoperable before disposal in the refuse dumpster. Nondisposable sampling items will be decontaminated.

Decontamination fluids that may be generated in the sampling events will consist of deionized water, residual contaminants, and water with non-phosphate detergents. The volume and concentration of the decontamination fluid will be sufficiently low to allow disposal at the site or sampling area. The water will be poured onto the ground or into a storm drain or into the surface water.

9.0 Documentation, Packaging and Shipment

9.1 Sample Documentation

All activities conducted at each sampling location will be documented in field notebooks. Specific locations will be surveyed via GPS units. Field logbooks will document where, when, how, and from whom any vital project information was obtained. Logbook entries will be complete and accurate enough to permit reconstruction of field activities. Logbooks are bound with consecutively numbered pages. Each page will be dated and the time of entry noted in military time. All entries will be legible, written in black ink, and signed by the individual making the entries. Language will be factual, objective, and free of personal opinions or other terminology which might prove inappropriate.

At a minimum, the following information will be recorded in the field notebook during the collection of each sample (Chain-of-Custody records will be used to trace the custody of the sample shipment container from the field to the laboratory):

- Sample location and sample ID number
- Names of sampling personnel
- Date and time of sample collection
- Type of sample (i.e.,$ClO4^-$)
- Site or sampling area sketch showing sample location and distances
- Field observations and details important to analysis or integrity of samples (e.g., heavy rains, odors, colors, divergence of protocols etc.)
- Preliminary sample descriptions (e.g., for produced water: brown water with a strong sulfur odor)
- Method and results of field measurements
- Shipping arrangements
- Recipient laboratory

In addition to the sampling information, the following specifics will also be recorded in the field logbook for each day of sampling:

- Location and number of any photos
- Time of site arrival/entry on site and time of site departure
- Complications encountered in sampling
- Other personnel on site
- A summary of any meetings or discussions with any operators, samplers, or federal, state, or other regulatory agencies
- Deviations from split sampling plans, site safety plans
- Changes in personnel and responsibilities as well as reasons for the changes

9.2 Photographs

If photographs are taken, they will be taken at the sampling locations and at other areas of interest on site or sampling area. They will serve to verify information entered in the filed paperwork. For each photograph taken, a description of the subject photographed will be included.

9.3 Labeling

All samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. At a minimum, the following information will be recorded on the sample bottles with a permanent marker.

Every sample, including samples collected from a single location but going to separate laboratories, will be assigned a unique sample number. The bottle will have the following information recorded:

a. Site location & sample ID

b. Date and time of grab sample

c. Collector initials

d. Analysis requested

The labeling protocols have been assigned by program conducting the sampling. ADEQ's groundwater program will assign sample identification numbers as:

PGW-__; the Clean Lakes Program PCL-__; the Surface Water Monitoring Program PSW-__; and ADWR's samples will be coded PDWR-__.

Samples will be numbered consecutively by the programs by trip. Split, duplicate, blank or spiked samples will be determined by trip and mixed into the sampling numbering system randomly. The bottles for these QA/QC samples shall be marked identically to other samples so that the receiving lab is not aware of the nature of the sample.

9.4 Chain-Of-Custody Forms

Chain-of-custody is a documented record which tracks the transfer of responsibility for the sample from one person to another. The field personnel initially collecting the sampling will be responsible for the care and custody of the sample until it is properly transferred to laboratory personnel or to airborne delivery service.

All sample shipments for analyses will be accompanied by a chain-of-custody record Form(s) will be completed and sent with the samples for each laboratory and each shipment (e.g., daily, weekly) If multiple coolers are sent to the laboratory on a single day, form(s) will be completed and sent with the samples for each cooler. The COC record will provide the project number, sample name, samples of samplers, site location, sample matrix, number of containers and the analysis required. The sample numbers for all samples including QA/QC samples will be documented on this form.

The chain-of-custody form will identify the contents of each shipment and maintain the custodial integrity of the samples. Generally, a sample is considered to be in someone's custody if it is either in someone's physical possession, in plain view after being placed in someone's possession, or locked in a secured area that is restricted to authorized personnel. The sampling team leader will sign the chain-of-custody form in the "relinquished by" box and note date and time of turn over to the laboratory. For airborne delivery, a custody seal is placed across the lid of each sample container. All custody seals will be signed and dated.

10.0 Quality Assurance/Quality Control

To assure the quality of data obtained during sampling, several types of Quality Assurance/Quality Control (QA/QC) measures will be taken. QC samples, including duplicates, splits, equipment and travel blanks and spiked samples, are submitted for analysis in the same manner as the other field samples, with no distinguishing marks or labels.

Field Duplicates: Duplicates are two identical samples, collected from the same source at the same time and submitted to the same laboratory. For this project, approximately 10% of the samples will be duplicate samples. The duplicate will be assigned a unique sample number and sent "blind" to Del Mar Laboratory. Duplicate samples will be collected, numbered, packaged and sealed in the manner as the other samples so that the duplication is unknown to laboratory personnel performing the analysis.

Duplicate samples are used to check laboratory handling and analytical procedures. Results shall be deemed acceptable if within 10% of the average of the two values reported. This criteria will not apply if the values are below the practical quantification limit.

Splits: Split samples are two identical samples, collected from the same source at the same time but submitted to two or more different laboratories for analysis. For this project, approximately 10% of the samples will be split samples.

Split samples for this project will be sent to Montgomery Watson Laboratory for analysis. Results shall be deemed acceptable if within 10% of the average of the two values reported. This criteria will not apply if the values are below the practical quantification limit.

Field Equipment and/or travel blanks: To the degree it is reasonable, at least one equipment blank or travel blank will be collected per trip using reagent-grade de-ionized water for analysis using the same method and protocols as the samples. The blanks will be numbered, packaged and sealed in a manner identical to the other samples collected. The analysis of this sample is used as a check against sample contamination using equipment, during collection, during transportation or within the laboratory.

Blanks should not contain any detectable concentration of method analytes. In the case of apparent contamination (e.g., two times the method detection limit), the analyst must determine the source of the contamination in order to effect its elimination before sample analysis can proceed. The concentration of any contaminants found in the blank analyses will not be used to correct sample analytical results. If blank contamination is low as compared to sample results, the results may still be meaningful. If contamination is present in blanks but not in samples, the sample results may also be acceptable. In general, resampling will be used to confirm questionable data.

Spiked Samples:

Laboratory quality control samples are analyzed by the contract laboratory as part of the standard quality control protocols. A spike of known concentration of the analyte of interest is prepared by a second laboratory (in this project ~ Montgomery Watson) for analysis by the primary lab – Del Mar Laboratory. A spike of a certain concentration is added to these samples to determine the reproducibility of the test methods and the effectiveness of quantitative techniques used in the lab. The results shall be deemed acceptable if within 10% of the actual spiked concentration.

For this project, Montgomery Watson shall provide samples spiked with the following concentrations: 4 ug/L, 8 ug/L and 40 ug/L. These spiked samples will be numbered, packaged and sealed in a manner identical to the other samples collected and submitted to Del Mar for analysis. At a minimum, one set each of the spikes will be analyzed per sample matrix – groundwater, lake water, surface water.

11.0 Field Health and Safety

11.1 Purpose and Applicability

This Health and Safety Plan addresses the procedures that will be followed by all personnel at the work site either engaged in work or present on site as a visitor. This Plan will remain in effect for the duration of the sampling activities unless modified based on site conditions by field personnel who will document such changes in field notebooks. A list of Hospital Emergency Rooms throughout the state are found in Appendix D.

11.2 General Rules

11.2.1 Personal safety always has priority over samples and sample collection.

11.2.2 Field work should generally involve at least two staff.

11.2.3 Each team member is responsible for dressing appropriately for the conditions, including rain gear and warm, dry clothes and footwear.

11.2.4 Staff will file a "field routing form" with at least one contact person. The form will outline where and when sampling is planned, where staff will staff when out of town, and emergency contact phone numbers.

11.2.5 Staff are required to check in at least once per day with the designated contact person – to ensure safety of personnel.

11.3. Hazard Assessment

Sampling activities may have the potential of exposing project personnel to chemical and physical hazards. These hazards are described in ***Table 11.1***, along with ways to avoid these hazards.

Table 11.1 Health and Safety Concerns

Area of Concern	Low	Med	High	Precautions
Explosion potential	x			Avoid working in confined spaces. No smoking during sample collection.
Oxygen deficiency	x			Avoid working in confined spaces.
Radiation	x			None required.
Skin/eye contact		x		Wear safety glasses & latex gloves.
Heat/cold stress		x		Carry adequate drinking water in field. Take rest breaks. Watch personnel for clamminess, fatigue, light headedness, nausea.
Falling objects	x			None required.
Falls		x		Always work in pairs, place cones around obstacles.
Confined space (e.g., wellhouse)	x			Always work in pairs, assess confined space and take precautions. If conditions are not safe, do not take sample.
Mechanical/electrical (e.g., well pumps,)	x			Be aware of and use normal precautions and proper tools when working around electrical and mechanical equipment.
Traffic		x		Traffic cones will be placed where necessary and all individuals working in traffic zones will be equipped with orange vests. For sites with high traffic concerns, a third team member should ensure traffic is mitigated while sampling is being conducted.
Drowning		x		All personnel shall wear personal flotation devices at all times when sampling from a boat, atop a canal or a surface water flowing greater than 3 cfs.
Lightning		x		Caution should be taken to avoid being on the water during storm events, especially those events where lightening is likely.

11.4 Special Precautions for Lake Sampling

Each team member will be responsible to have the appropriate personal flotation device (PFD) while on the lake. The pontoon boat is equipped with the following safety items: emergency shut-off, fire extinguisher, first aid kit, flares, PFDs, horn, running lights, depth finder and tool box.

11.5 Personal Protective Equipment

Based on the potential elemental exposures, Level D protection will be used during sampling. Wide brimmed hats are recommended to be worn for protection from the sun. At a minimum eye protection will be worn. This will consist of safety glasses or goggles. Nitrile gloves may be worn when skin contact with contaminated water is likely.

11.6 Emergency Response

One staff member within each sampling team will act as a Team Health and Safety Officer. All safety officers will be equipped with a cellphone or a satellite phone, depending on the remoteness of the sampling route. In the event of an emergency, the Team Safety Officer will contact the nearly emergency response center to arrange transport of the injured person to a care facility. A list of hospitals throughout the state are included as an appendix. All sampling teams will have a first-aid kit on hand to assist with any on-site injuries. All injuries will be documented.

12.0 Budget

Analysis for Perchlorate using EPA Method 314 modified:
  Del Mar Laboratory $80/ sample
  Montgomery Watson $100/sample

Preparation of spiked samples at concentrations of 4 ug/L, 8 ug/L, 40 ug/L
  Montgomery Watson

No. of samples	***Purpose***	***Laboratory***	***Cost***	***Total***
100	Characterization	Del Mar	$80	$8000
10	QA/QC -- duplicates	Del Mar	$80	$ 800
10	QA/QC – splits	Mont Watson	$100	$1000
15	QA/QC – equipment/travel blanks	Del Mar	$80	$1200
3	Spikes @ 4 ug/L prep	Mont Watson	$30	$ 90
3	Spikes @ 8 ug/L prep	Mont Watson	$30	$ 90
3	Spikes @ 40 ug/L prep	Mont Watson	$30	$ 90
3	Spikes @ 4 ug/L analysis	Del Mar	$80	$ 240
3	Spikes @ 8 ug/L analysis	Del Mar	$80	$ 240
3	Spikes @ 40 ug/L analysis	Del Mar	$80	$ 240
153	**TOTALS**	**N/A**	**N/A**	**$11,990**

Appendix A1

GROUNDWATER FIELD METHODS

General Sample Collection Procedure

1. At each sampling site, information such as arrival time, well owners address and signature, site and well location, and other information will be recorded in a preprinted field book.

2. Prior to sampling, when possible, a decontaminated sounder or water level indicator will be used to determine depth to water (measured from the top of the well casing to the top of the water surface to the nearest 0.1-foot). The height of the well casing to ground level will be subtracted from the measurement. The sounder probe will be released to the bottom of the well to determine the well depth and to check well log information.

3. Ground surface and top of casing elevations will be interpolated from the topographic map of the area so that a groundwater elevation may be calculated.

4. The water volume in the casing will be calculated.

5. Pumping rate will be measured and recorded. The pumping rate and the volume of water in the casing will be used to calculate the length of time necessary to remove three bore volumes. A minimum of three casing volumes of water will be purged or removed from the well prior to sampling using a dedicated submersible pump or disposable bailers, except when field conditions dictate this amount cannot be met.

6. Specific conductivity, pH, and temperature (Celsius) will be measured using a Hydrolab, a multi-parameter instrument. While purging the well, measurements will be recorded at five-minute or less intervals. Purging of the well is deemed complete when at least three casing volumes of water have been removed and the parameters have stabilized to 10 percent or less difference between the last three successive readings.

7. Each sample bottle will be properly labeled.

8. Bottles will be preserved at 4 degrees Celsius in an ice chest. Holding time is 28 days.

9. A GPS unit will be used to obtain precise latitude/longitude readings at each wellhead.

10. Digital photographs will be taken showing the well, it's location in relation to easily-discernible landmarks, and the nearby land uses.

FIELD EQUIPMENT

Sampling equipment which may be used during the study:

Equipment Function

YSI or Hydrolab multi-parameter field measurements: pH, Specific Conductance, and Temperature

Water Level Indicator: Measurement of static groundwater levels

Sounder: Measurement of static groundwater levels

1 Liter Bailers (disposable): Purging and sample collection from wells with small diameter casings without dedicated pumps

250 ft. Grundfos Pump: Well purging and sample collection from wells without dedicated pumps

Camera: Photos of wells and sampling procedures

Global Positioning System (GPS): Collection of GPS points to determine latitude and longitude of wellheads

5 Gallon Bucket: Used for discharge rate

Ice Chest: To maintain sample temperature of 4 degrees Celsius or less

Appendix A2

LAKE MONITORING FIELD METHODS

Field measurements and equipment (see LPM):

The Lakes Program uses one of three boats, depending upon the size of the lake and ease of access. Field measurements of physical/chemical water conditions are taken using either a Hydrolab H2O or a YSI 6600 datasonde (multiprobe). Parameters measured include depth, temperature, dissolved oxygen (DO) in mg/L and percent saturation, pH, electrical conductivity (EC), Redox potential (ORP), and TDS at a minimum. These depth profile measurements indicate the degree of stratification in the water column and assist with the decision of where to pull water samples. Multi-probe data are stored and later downloaded directly to the database. Air temperature and current conditions are also recorded.

Water clarity is measured using a Secchi Disk dropped to the point at which it disappears from view. Clarity is also measured using a Hach Turbidimeter 2100.

Sample collection procedures and equipment:

Water samples are collected with either a Van Dorn or Beta bottle. These devices are opened and lowered through the water column to the desired depth. A weight is sent down the line to trip the mechanism and a depth-specific sample is collected. The water samples are pulled to the surface and decanted into non-preserved, pre-labeled sample bottles. Filled bottles are placed on ice in a cooler.

Field activity documentation:

Pre-prepared field sheets are filled out for each lake sample site. Field sheets are used to record information on date, times, conditions, depth profile readings, sampling depths, secchi depth, turbidity, and anecdotal information on wildlife or human activities. These sheets become a permanent part of the lake site file. A global positioning system (GPS) will be used to obtain precise latitude/longitude readings at each sampling location.

Appendix A3

SURFACE WATER FIELD METHODS

FOR GRAB SAMPLES: Stand in the stream at the location which is representative of the entire flow. This is usually in the middle of the stream. However, if the majority of the flow is elsewhere, take the sample there. Rinse an empty sample cell several times with stream water.

Water Quality Sample Collection Procedures

a. Equipment needed:

   i. One liter wide-mouthed sample collection bottle for each site.
   ii. A 1-liter unpreserved sample
   iii. Churn splitter for each site where EWI or modified EWI sample collection procedures are used or you have to do a QA / QC split sample.

b. Grab Sample Equal-Width-Increment Sample (EWI)

   EWI sampling should be used when one or more of the following conditions occur:

   i. Stream depth is one foot deep or greater for the majority of the channel.
   ii. Stream velocity exceeds 1.0 ft / sec. for the majority of the channel.
   iii. You are sampling a stream where tributary flows may not be completely mixed with the main stream flow.

   Grab samples are O.K when all of the following conditions occur:

   i. Stream depth is less than 1 foot deep for the majority of the channel
   ii. Stream velocity is 1.0 ft. / sec. or less for the majority of the channel.
   iii. There is no influence of tributary flows or it is your best professional judgment that the stream is completely mixed.
   iv. Stream is not very wide (less than 10 feet across).

   Use Modified EWI sampling when you have a wide, shallow stream but conditions for EWI sampling are not met or EWI is not practical.

c. Grab sample collection procedures:

   i. Collect water samples after all field measurements have been taken with Hydrolab and discharge measurements are completed.

   ii. Go to middle of the channel. Face upstream.

iii. Use a 1-liter wide-mouthed sample collection bottle. Submerge the bottle halfway between the surface of the water and the stream bed.

iv. Make sure all of the sample bottles are properly labeled before placing them into the ice chest and before leaving the site.

v. Place all samples in the ice chest immediately after labeling. Keep the samples in ice chest until they are delivered to the laboratory.

d. Equal-Width-Increment (EWI) Sample Collection Procedures

i. Equipment needed: DH81 hand-held sampler, 1-liter sample collection bottle, nozzle, and a churn splitter.

ii. Place measuring tape across stream channel and take discharge measurements.

iii. Determine the number of intervals that need to be sampled along a cross-section based on the sample volume needed to fill all of sample bottles (usually 4 liters), the size of the churn splitter (usually 8), whether the sample will be split, and the depth and velocity distribution in the cross section.

iv. Determine the proper transit rate. Go to the deepest, fastest vertical in the channel. Face upstream. Lower the DH81 sampler to the bottom and pull it back up to the surface at a uniform rate. Through trial and error, determine the rate that you have to lower and raise the DH81 sampler to fill the 1-liter collection bottle without overfilling it. The sample bottle is overfilled when the water level in the sample collection bottle is above the base of the nozzle when the sampler is held level. Don't speed up or slow down. The rates of descent and ascent of the DH81 sampler must be equal (It may take several tries to establish the proper transit rate to obtain a 1-liter subsample in the deepest, fastest part of the channel). Once you determine the proper transit rate, use the same transit rate at the other verticals where sub-samples are taken.

v. Go to the furthest bank and prepare to collect sub-samples at the established intervals using the proper transit rate. The first sub-sample should be taken at a point that is ½ the distance of the selected increment from the bank. For example, if the stream width is 20 feet and the number of verticals necessary is 10, the width of each increment would be 2 feet. The first sub-sample would be taken at the center of the first increment, beginning at a location of 1 foot from the bank.

vi. Face upstream at the selected vertical and lower the DH81 sampler at the predetermined transit rate. Place the collected sub-sample in the churn splitter.

vii. Move to the next vertical and repeat the sampling procedure. It may be possible to sample at two or more verticals without having to empty the sample collection bottle into the churn splitter. If you think there's a chance of overfilling the bottle, empty the sub-sample into the churn splitter and start fresh with an empty 1-liter sample collection bottle.

e. Modified EWI

The modified EWI procedure is similar to the EWI procedure except that instead of using the DH81 sampler, sub-samples are collected by hand by lowering a 1-liter sample bottle with the open end facing upstream. Again, the sample bottle is moved through the water column at a constant transit rate. Like the EWI method, the collected sub-samples are emptied into a churn splitter. The modified EWI method is typically used when you have a wide, shallow stream (less than 1 foot deep) and it is not practical to use the DH81 sampler. Fewer sub-samples are usually collected because wide-mouth sample collection bottles fill more quickly at each interval.

Appendix A4

HOSPITAL EMERGENCY ROOMS

Emergency information:

Emergency Telephone Numbers: (use 911 where appropriate)
Fire: 911
Police: 911
Ambulance: 911

Nearest Hospital Emergency Room:

1. **Colorado Mainstem**:

   Havasu Regional Medical Center
   101 Civic Center Lane
   Lake Havasu City (928) 855-8185

   La Paz Regional Hospital
   1200 Mohave Road
   Parker (928) 669-9201

2. **Bill Williams Basin**:

   Kingman Regional Medical Center
   3269 Stockton Hill Road
   Kingman (928) 757-2101

   Wickenburg Regional Medical Center
   520 Rose Lane
   Wickenburg (928) 684-5421

   La Paz Regional Hospital
   1200 Mohave Road
   Parker (928) 669-9201

3. **Lower Gila River Basin**:

   Yuma Regional Medical Center
   2400 S. Avenue A
   Yuma (928) 344-2000

4. **Salt River Basin:**

Payson Regional Medical Center
807 S. Ponderosa Street
Payson (928) 474-3222

White Mountain Regional Medical Center
118 S. Mountain Avenue
Springerville (928) 333-4368

Cobre Valley Community Hospital
5880 S. Hospital Drive
Gl**obe** (928) 425-3261

5. **Verde River Basin:**

Yavapai Regional Medical Center
1003 Willow Creek Road
Prescott (928) 445-2700

Sedona Medical Center
3700 W. Hwy 89A
Sedona (928) 204-3000

Verde Valley Medical Center
269 S. Candy Lane
Cottonwood (928) 634-2251

Payson Regional Medical Center
807 S. Ponderosa Street
Payson (928) 474-3222

6. **Middle Gila River Basin:**

Wickenburg Regional Medical Center
520 Rose Lane
Wickenburg (928) 684-5421

Yavapai Regional Medical Center
1003 Willow Creek Road
Prescott (520) 445-2700

John C. Lincoln Hospital
19829 N. 27th Avenue (I-17 & 101)
Phoenix (623) 879-6100

West Valley Emergency Center
Goodyear (623) 245-6700

Mayo Clinic Hospital
5777 E. Mayo Boulevard (near the 101)
Phoenix (480) 515-6296

Mesa Lutheran
525 W. Brown Road (near Hwy. 87)
Mesa (480) 834-1211

Valley Lutheran Medical Center
6644 E. Baywood Avenue (in east Mesa)
Mesa (480) 981-2000

Casa Grande Regional Medical Center
1800 E. Florence Boulevard
Casa Grande (520) 426-6300

7. **Little Colorado River Basin:**

NavApache Regional Medical Center
Holbrook (928) 537-4375

Winslow Memorial Hospital
1501 Williamson Avenue
Winslow (928) 289-4691

White Mountain Regional Medical Center
118 S. Mountain Avenue
Springerville (928) 333-4368

Navapache Regional Medical Center
2200 Show Low Lake Road
Show Low (928) 537-4375

Flagstaff Medical Center
1200 W. Beaver Street
Flagstaff (928) 779-3366

8. **Upper Gila River Basin:**

White Mountain Regional Medical Center
118 S. Mountain Avenue
Springerville (928) 333-4368

Mt. Graham Community Hospital
1600 20th Avenue
Safford (928) 348-4000

Appendix B

Sampling Sites and Results for 2004 Sampling Effort

Map No.	Site Location	Source	Date Samples Collected	Results (ppb)	Reporting Limits (ppb)	Collection Entity	New or Existing	County	Latitude	Longitude
1	ADEQ MW-3	GW	6/15/2004	ND	2	GWMU		Yuma	32.705830	-114.598060
2	ADEQ MW-3	GW	6/17/2004	2.5	2	GWMU		Maricopa	33.357220	-112.641670
3	ADEQ MW-8	GW	6/17/2004	ND	2	GWMU		Maricopa	33.278890	-112.780280
4	ADEQ MW-12	GW	6/15/2004	3.4	2	GWMU		Yuma	32.570830	-114.709170
5	ADEQ MW-24	GW	6/15/2004	7.4	2	GWMU		Yuma	32.581670	-114.715280
6	ADEQ MW-30	GW	6/15/2004	15	2	GWMU		Yuma	32.755000	-114.004440
7	Agua Fria Managed/Construc	RE	7/27/2004	4.8	2	DWR		Maricopa	33.710639	-112.293056
8	Agua Fria Managed/Construc	RE	7/27/2004	4.3	2	DWR		Maricopa	33.730361	-112.289389
9	Avra Valley Recharge	RE	7/13/2004	2.4	2	DWR		Pima	32.416833	-111.216000
10	Bartlett Lake (surface)	SW	7/7/2004	ND	2	CLP		Maricopa	33.817780	-111.627500
11	Bartlett Lake @ depth	SW	7/7/2004	ND	2	CLP		Maricopa	33.817780	-111.627500
12	Ben Barker	GW	6/16/2004	ND	2	GWMU		La Paz	33.376580	-114.663290
13	Bill Williams Watershed	GW	5/11/2004	ND	2	GWMU		La Paz	34.245556	-113.951389
14	Buckskin State Park	GW	6/10/2004	ND	2	GWMU		La Paz	34.152723	-114.094234
15	CAP Canal @ 99th Ave	SW	2/9/2004	4.2	2	CAP	E	Maricopa	33.779556	-112.246500
16	CAP Canal abv Lake Pleasant	SW	2/10/2004	4	2	CAP	E	Maricopa	33.780830	-112.293560
17	CAP Canal blw Lake Pleasant	SW	2/10/2004	3	2	CAP	E	Maricopa	33.779380	-112.246720
18	CAP Canal@ McKellips bridge	SW	7/7/2004	2.7	2	DWR		Maricopa	33.465917	-111.680556
19	CAP Canal (Little Harq PP)	SW	7/7/2004	3.2	2	DWR		La Paz	33.060367	-113.620556
20	CAP Canal (San Xavier PP)	SW	7/13/2004	2.3	2	DWR		Pima	32.162222	-111.130611
21	CAVSARP	RE	7/8/2004	2.4	2	DWR		Pima	32.243333	-111.246556
22	CAVSARP	RE	7/8/2004	2.3	2	DWR		Pima	32.250694	-111.257333
23	CAP Canal (Wilmer PP)	SW	2/18/2004	4.2	2	CAP	E	La Paz	34.288722	-114.103278
24	Central AZ Irrigation & Drainage District	GW	6/17/2004	ND	2	DWR		Pinal	32.661556	-111.594222
25	Central AZ Irrigation & Drainage District	GW	6/17/2004	ND	2	DWR		Pinal	32.792472	-111.507220
26	City of Chandler Tumbleweed Recharge	RE	6/22/2004	ND	2	DWR		Maricopa	33.276528	-111.824972
27	City of Mesa Red Mountain Lake	SW	5/12/2004	2.9	2	CLP		Maricopa	33.434720	-111.668610
28	City of Peoria – Beardsley Recharge	RE	7/6/2004	ND	2	DWR		Maricopa	33.660333	-112.300417

29	Colorado River @ Imperial Dam	SW	5/17/2004	3.6	2	CLP		Yuma	32.883060	-114.464170
30	Colorado River @ Morelos Dam	SW	6/15/2004	2.4	2	GWMU		Yuma	32.708370	-114.724750
31	Colorado River @Topock	SW	5/19/2004	3.9	2	CLP		Mohave	34.714720	-114.485280
32	Colorado River @ Headgate Rock Dam	SW	5/17/2004	3.5	2	CLP		La Paz	34.167780	-114.275830
33	DeJong Dairy	GW	6/22/2004	ND	2	DWR		Maricopa	33.261750	-111.748444
34	Ehrenberg area	GW	6/16/2004	ND	2	GWMU			33.595470	-114.529530
35	Fullmer Cattle Co.	GW	6/16/2004	ND	2	DWR		Maricopa	33.377056	-112.463694
36	Gila Main Canal	SW	5/17/2004	3.3	2	CLP		Yuma	32.876110	-114.455000
37	Gila River @ Gillespie Dam	SW	6/30/2004	ND	2	FSN		Maricopa	33.228890	-112.768330
38	Gila River blw 91st Ave	SW	6/30/2004	2.1	2	FSN		Maricopa	33.382780	-112.257780
39	Glendale Arrowhead Recharge	RE	8/12/2004	ND	2	DWR		Maricopa	33.656694	-112.234722
40	Granite Reef Underground Storage	RE	6/21/2004	ND	2	DWR		Maricopa	33.489889	-111.751639
41	Granite Reef Underground Storage	RE	6/21/2004	2.7	2	DWR		Maricopa	33.492444	-111.769472
42	Harquahala Southwestern	GW	7/6/2004	ND	2	DWR		Maricopa	33.391972	-113.178583
43	Hogenes Dairy	GW	6/16/2004	ND	2	DWR		Pinal	33.070611	-112.065167
44	Horvath Domestic Well	GW	6/9/2004	ND	2	GWMU		Mohave	35.020155	-114.352702
45	Lake Havasu	SW	5/18/2004	4.4	2	CLP		Mohave	34.451670	-114.335560
46	Lake Havasu	SW	5/18/2004	3.7	2	CLP		Mohave	34.541940	-114.386940
47	Lake Havasu	SW	5/18/2004	4.4	2	CLP		Mohave	34.291390	-114.108060
48	Bill Williams River abv Havasu	SW	5/11/2004	ND	2	GWMU		Mohave	34.254654	-114.009227
49	Lake Havasu	SW	5/18/2004	3.5	2	CLP		Mohave	34.297780	-114.138060
50	Lake Mead	SW	3/31/2004	6	2	NDEP	E	Mohave	36.069170	-114.801100
51	Lake Pleasant (surface)	SW	6/29/2004	2.2	2	CLP	E	Maricopa	33.848870	-112.270130
52	Lake Pleasant (at depth)	SW	6/29/2004	2	2	CLP	E	Maricopa	33.848870	-112.270130
53	Lake Pleasant (river input)	SW	2/10/2004	ND	2	CAP	E	Maricopa	33.905410	-112.245650
54	Lake Pleasant (midlake)	SW	2/10/2004	3	2	CAP	E	Maricopa	33.891630	-112.276440
55	LHC Monitoring Well #MW-2B	GW	6/9/2004	ND	2	GWMU		Mohave	34.274975	-114.211340
56	LHC Monitoring Well #MW-5B	GW	6/9/2004	ND	2	GWMU		Mohave	34.272861	-114.220742
57	LHC Monitoring Well #MW-9B	GW	6/9/2004	ND	2	GWMU		Mohave	34.274869	-114.202788
58	Lucas Domestic Well	GW	6/9/2004	<4[1]	4	GWMU		Mohave	34.523896	-114.373117
59	Main Outlet Drain (MODE canal)	SW	6/15/2004	ND	2	GWMU		Yuma	32.498870	-114.785410
60	Maricopa Stanfield Irrigation District	GW	6/16/2004	ND	2	DWR		Pinal	32.865056	-111.911722
61	Maricopa Stanfield Irrigation District	GW	6/16/2004	ND	2	DWR		Pinal	32.938250	-111.929250

62	Martinez Lake	SW	5/17/2004	ND	2	CLP		Yuma	32.981110	-114.476670
63	Mittry Lake	SW	5/17/2004	ND	2	CLP		Yuma	32.820560	-114.476670
64	N. Mohave Water Co. #7	GW	6/9/2004	ND	2	GWMU		Mohave	35.101606	-114.305924
65	N. Mohave Water Co. #9	GW	6/9/2004	ND	2	GWMU		Mohave	35.092549	-114.324336
66	Papago Park Lakes	SW	5/12/2004	ND	2	CLP		Maricopa	33.454440	-111.944720
67	Roosevelt Lake (surface)	SW	6/3/2004	ND	2	CLP		Gila	33.674170	-111.156110
68	Roosevelt Lake @ depth	SW	6/3/2004	ND	2	CLP		Gila	33.674170	-111.156110
69	Roosevelt Water Conservation District	GW	6/22/2004	ND	2	DWR		Maricopa	33.350139	-111.681806
70	SRP Arizona Canal	SW	6/21/2004	ND	2	DWR		Maricopa	33.512306	-111.695250
71	SRP Southern Canal	SW	6/21/2004	ND	2	DWR		Maricopa	33.515000	-111.699306
72	San Carlos Irrigation District	GW	6/17/2004	ND	2	DWR		Pinal	33.049417	-111.455417
73	San Carlos Irrigation District	GW	6/17/2004	ND	2	DWR		Pinal	32.837833	-111.672806
74	San Pedro River	SW	6/24/2004	ND	2	FSN		Cochise	31.626800	-110.174133
75	Santa Cruz River nr Tucson	SW	6/24/2004	<4 [1]	4	FSN		Pima	32.298400	-111.041283
X	Santa Cruz River nr Nogales	SW	6/24/2004	<20 [2]	20	FSN		Santa Cruz	31.469750	-110.992083
76	Sweetwater Underground Storage	RE	7/8/2004	ND	2	DWR		Pima	32.277250	-111.027417
77	Sweetwater Underground Storage	RE	7/8/2004	ND	2	DWR		Pima	32.281306	-111.029028
78	Topock Marsh	SW	5/19/2004	ND	2	CLP		Mohave	34.836110	-114.584170
79	Town of Parker #7	GW	6/10/2004	ND	2	GWMU		La Paz	34.083704	-114.170068
80	Town of Parker #8	GW	6/10/2004	ND	2	GWMU		La Paz	34.085176	-114.173574
81	Town of Parker #6	GW	6/10/2004	ND	2	GWMU		La Paz	34.092042	-114.170068
82	Wellton and Mohawk Canals	SW	6/15/2004	2.6	2	GWMU		Yuma	32.742300	-114.432660
83	Willow Beach on Colorado River	SW	5/7/2004	4.5	2	NDEP	E	Mohave	35.873889	-114.661944
84	Yoney Auto Shop	GW	6/9/2004	ND	2	GWMU		Mohave	34.515523	-114.343483
85	Yoney Domestic Well	GW	6/9/2004	ND	2	GWMU		Mohave	34.534519	-114.353190
86	Yuma Proving Ground	GW	6/16/2004	ND	2	GWMU		Yuma	32.842210	-114.392730
87	Yuma Proving Ground	GW	6/16/2004	ND	2	GWMU		Yuma	32.838920	-114.386670

X = not on map due to high detection limit due to need to dilute sample 10X

Legend:

1: Source
- GW = Groundwater
- IND = Industrial Facility
- RE = Recharge Facility
- SW = Surface Water

2. Collection Entity
- CAP – Central Arizona Project
- CLP = ADEQ's Clean Lakes Program
- DWR = Department of Water Resources
- GWMU = ADEQ's Groundwater Monitoring Unit
- NDEP = Nevada Department of Environmental Protection
- SWMU = ADEQ's Surface Water Monitoring Unit

APPENDIX C

Sampling Sites and Results for Monitoring Prior to 2004

Map #	Site Location	Site Identification	Source	Data Samples Collected	Results (ppb)	Reporting Limit (ppb)	Collection Entity	Latitude	Longitude	County
1	All American Canal	S of Imperial Dam	SW	4/21/1999	5.10	4	ASUA	32.872826	-114.478386	Yuma
2	Avra Valley	CAP recharge	RE	5/13/1999	ND	4	ASUA	32.588349	-111.402544	Pima
3	Bill Williams NWR	east of Colorado Rv	SW	4/18/1999	ND	4	ASUA	34.298869	-114.087800	Mohave
4	CAP nr Florence	crossing Hwy 79	SW	5/13/1999	ND	4	ASUA	33.078519	-111.373386	Pinal
5	Chemehuevi IR	river chan top	SW	4/17/1999	5.40	4	ASUA	34.548098	-114.394297	Mohave
6	Chemehuevi IR	river chan bot	SW	4/17/1999	6.10	4	ASUA	34.548098	-114.394297	Mohave
7	Chemehuevi IR	irrigation	GW	4/17/1999	5.70	4	ASUA	34.521549	-114.394722	Mohave
8	Chemehuevi IR	Havasu Palms well	GW	4/18/1999	ND	4	ASUA	34.400661	-114.277069	Mohave
9	Cibola NWR	Colo Rv shoreline	SW	4/20/1999	5.40	4	ASUA	33.302886	-114.676847	La Paz
10	Colo Rv Indian Tribe	Big River well	GW	4/19/1999	ND	4	ASUA	34.120602	-114.377814	La Paz
11	Colo Rv Indian Tribe	main irrig canal	SW	4/19/1999	6.20	4	ASUA	34.013241	-114.389406	La Paz
12	Colo Rv Indian Tribe	Colorado Rv mainstem	SW	4/19/1999	6.40	4	ASUA	34.042498	-114.434383	La Paz
13	Deer Valley WTP	raw water	SW	2/22/2002	ND	4	COP	33.569966	-112.124025	Maricopa
14	FMTUA	tribal HQ well	GW	4/16/1999	ND	4	ASUA	34.918671	-114.630358	Mohave
15	Gila River	Florence	SW	5/13/1999	ND	4	ASUA	32.872826	-114.478386	Pinal
16	LA intake Lake Havasu	in lake b4 intake	SW	4/18/1999	5.90	4	ASUA	34.316900	-114.156706	California
17	Lake Havasu	Well #15	GW	2/17/2000	ND	4	COP	34.505556	-114.359444	Mohave
18	Lake Havasu	Well #16	GW	2/17/2000	ND	4	COP	34.464722	-114.337500	Mohave
19	Lake Mary WTP	gw well	GW	9/13/1999	ND	4	ASUA	35.150106	-111.650700	Coconino
20	Lake Mary WTP	raw water	SW	9/13/1999	ND	4	ASUA	35.109085	-111.585589	Coconino
21	Lake Mary WTP	raw water	SW	9/13/1999	ND	4	ASUA	35.159163	-111.715108	Coconino
22	Lake Mead	Kingman Wash surface	SW	4/15/1999	8.50	4	ASUA	36.035573	-114.707842	Mohave
23	Lake Mead	Kingman Wash bottom	SW	4/15/1999	8.50	4	ASUA	36.035573	-114.707842	Mohave
24	Lake Mead	S. Cove offshore	SW	4/14/1999	ND	4	ASUA	36.092245	-114.088922	Nevada
25	Lake Mohave	Katherine Landing surface	SW	4/16/1999	6.50	4	ASUA	35.215363	-114.572914	Mohave
26	Lake Mohave	Katherine Landing bottom	SW	4/16/1999	6.30	4	ASUA	35.215363	-114.572914	Mohave
27	Lake Pleasant	towers @ dam	SW	2/15/2000	4.00	4	COP	33.844722	-112.271389	Maricopa
28	Lake Pleasant upstream	0.5 mi W 99th Ave	SW	2/15/2000	6.60	4	COP	33.781556	-112.286167	Maricopa

29	Las Vegas Bay	surface	SW	4/15/1999	160.00	4	ASUA	36.130017	-114.869564	Nevada
30	Las Vegas Bay	bottom	SW	4/15/1999	480.00	4	ASUA	36.130017	-114.869564	Nevada
31	N. Cocopah IR	gw well	GW	4/21/1999	ND	4	ASUA	32.738487	-114.692158	Yuma
32	N. Cocopah IR	Colo Rv shoreline	SW	4/21/1999	ND	4	ASUA	32.739929	-114.692175	Yuma
33	Navajo Army Depot	industrial	GW	5/18/1999	ND	4	ASUA	35.219149	-111.833729	Coconino
35	Red Rock	CAIDD	SW	5/13/1999	ND	4	ASUA	32.588349	-111.414036	Pinal
34	Park Shadows PWS	domestic well	GW	12/10/2003	3.00	2	GeoMatrix	33.444400	-112.345400	Maricopa
36	Salt River	Blue Pt bridge	SW	2/14/2000	ND	4	COP	33.518067	-111.684440	Maricopa
37	Squaw Peak WTP	raw water	SW	3/7/2000	ND	4	COP	33.526322	-112.032092	Maricopa
38	St. David	San Pedro	SW	5/22/1999	ND	4	ASUA	31.905449	-110.245828	Cochise
39	Union Hills WTP	raw water	SW	2/10/2000	5.10	4	COP	33.686848	-110.036503	Maricopa
40	Val Vista WTP	raw water	SW	2/15/2002	4.10	4	COP	33.466721	-111.760014	Maricopa
41	Verde River	Bush Hwy bridge	SW	2/14/2000	ND	4	COP	33.580804	-111.684440	Maricopa
42	Verde WTP	raw water	SW	2/15/2000	ND	4	COP	33.544988	-111.668011	Maricopa
43	Vidler Recharge Facility	DG-01	RE	12/3/2003	2.30	2	URS	33.558861	-113.386306	La Paz
44	Vidler Recharge Facility	DG-02	RE	12/3/2003	0.20	2	URS	33.559722	-113.397222	La Paz
45	Vidler Recharge Facility	UG-01	RE	12/3/2003	4.40	2	URS	33.565583	-113.395444	La Paz
46	Havasu Heights Water Co.	55-629451	GW	4/21/1999	ND	4	GWMU	34.6610633	-114.284451	Mohave
47	Caliche Spring	21174	GW	3/16/1999	ND	4	GWMU	34.925095	-114.221371	Mohave
48	Ranch House Well	55-638923	GW	3/3/1999	ND	4	GWMU	35.0378828	-114.006119	Mohave
49	Lookout Spring	21572	GW	3/17/1999	ND	4	GWMU	35.1173836	-114.049862	Mohave
50	Arnold	21725	GW	2/16/1999	ND	4	GWMU	35.2061389	-114.046524	Mohave
51	Claresa Spring	21793	GW	2/16/1999	6	4	GWMU	35.2302114	-114.38263	Mohave
52	Willow Spring	21921	GW	2/3/1999	ND	4	GWMU	35.2968064	-114.377054	Mohave
53	Hancock	55-601492	GW	4/21/1999	ND	4	GWMU	34.8108972	-114.116293	Mohave
54	ADOT Haviland Rest Area	55-628123	GW	3/16/1999	ND	4	GWMU	34.8321847	-114.142792	Mohave
55	Cunningham	55-632773	GW	2/2/1999	ND	4	GWMU	35.1688928	-114.071388	Mohave
56	Summers	55-506879	GW	2/3/1999	5.8	4	GWMU	35.3096508	-114.282723	Mohave
57	Haney	55-517211	GW	12/3/1998	ND	4	GWMU	35.0316364	-114.317244	Mohave
58	Yuma MW-21	55-570278	GW	9/17/2003	5.4	4	GWMU	32.7808378	-113.746541	Yuma
59	Yuma MW-19	55-570280	GW	9/17/2003	5.3	4	GWMU	32.7515953	-113.975974	Yuma
60	Yuma MW-14	55-570279	GW	9/18/2003	3.8	4	GWMU	32.7873206	-114.508656	Yuma
61	Van Meter	55-508555	GW	2/4/1999	ND	4	GWMU	35.4188064	-114.192119	Mohave
62	Leibold	55-602518	GW	2/3/1999	ND	4	GWMU	35.2627925	-114.14107	Mohave
63	Romero	55-534212	GW	2/2/1999	ND	4	GWMU	35.1599325	-114.321148	Mohave

64	Lander	55-555437	GW	2/3/1999	ND	4	GWMU	35.1287161	-113.957744	Mohave
65	Orr	55-565029	GW	2/4/1999	ND	4	GWMU	35.2369961	-114.055354	Mohave
66	Skeen	55-560184	GW	2/16/1999	ND	4	GWMU	35.1313553	-114.309652	Mohave
67	Stout	55-541211	GW	2/17/1999	ND	4	GWMU	35.3559722	-114.011472	Mohave
68	Haystack	55-805603	GW	3/2/1999	ND	4	GWMU	35.0323564	-114.073833	Mohave
69	Parker	55-543553	GW	3/2/1999	ND	4	GWMU	35.1036014	-114.16728	Mohave
70	Gist	55-529616	GW	3/3/1999	21	4	GWMU	35.0653275	-114.220252	Mohave
71	Rock Creek	55-805611	GW	3/3/1999	ND	4	GWMU	34.9522603	-114.053609	Mohave
72	Tyree Well	55-618231	GW	4/20/1999	ND	4	GWMU	34.7299614	-113.912208	Mohave
73	Bristol Well	55-543918	GW	4/21/1999	ND	4	GWMU	34.7537869	-114.205731	Mohave
74	Bingaman Well	55-543765	GW	4/22/1999	ND	4	GWMU	34.7927772	-114.129625	Mohave
75	House Well	55-614802	GW	3/18/1999	ND	4	GWMU	34.6574353	-113.741049	Mohave
76	L. Ernst #1	55-803930	GW	5/5/1999	ND	4	GWMU	34.6094844	-114.17889	Mohave
77	L. Ernst #2	55-803931	GW	5/5/1999	ND	4	GWMU	34.6169678	-114.181523	Mohave
78	El Paso	55-539067	GW	5/6/1999	ND	4	GWMU	34.5739844	-113.99307	Mohave
79	Halfway Well	55-642277	GW	4/6/1999	ND	4	GWMU	34.6343047	-113.740758	Mohave
80	Stouts Well	55-645966	GW	4/6/1999	15	4	GWMU	34.5906897	-113.794891	Mohave
81	Big Well	55-645970	GW	4/6/1999	ND	4	GWMU	34.4367631	-113.835466	Mohave
82	Castaneda Well	55-645969	GW	4/6/1999	ND	4	GWMU	34.4347264	-113.904149	Mohave
83	Banks Well	55-645965	GW	4/6/1999	ND	4	GWMU	34.5497072	-113.774844	Mohave
84	New Well #1	55-645967	GW	4/6/1999	ND	4	GWMU	34.64384	-113.825345	Mohave
85	New Well #2	55-645968	GW	4/6/1999	ND	4	GWMU	34.6435247	-113.825158	Mohave
86	Daryl's Well	55-614815	GW	4/6/1999	ND	4	GWMU	34.6830953	-113.779733	Mohave
87	Goat Spring	57946	GW	4/7/1999	ND	4	GWMU	34.8874422	-113.944154	Mohave
88	Old House Spring	57947	GW	4/7/1999	ND	4	GWMU	34.9138636	-113.940995	Mohave
89	Well #3	55-623083	GW	4/8/1999	ND	4	GWMU	35.1690311	-114.23418	Mohave
90	Christmas Well	57949	GW	4/8/1999	ND	4	GWMU	34.6682683	-113.890792	Mohave
91	Antelope Spring	57952	GW	3/17/1999	ND	4	GWMU	34.9668178	-114.305254	Mohave
92	Thornton Well	55-528814	GW	3/16/1999	ND	4	GWMU	35.1773417	-113.990127	Mohave
93	ADOT - Needle Mountain	55-628108	GW	3/16/1999	7.6	4	GWMU	34.7259586	-114.433267	Mohave
94	ADA Yuma MW#24	55-576587	GW	9/18/2003	7.3	4	GWMU	32.5817669	-114.715277	Yuma
95	ADA Yuma MW#25	55-576584	GW	9/18/2003	4.6	4	GWMU	32.5815361	-114.717708	Yuma
96	ADA Yuma MW#33	55-576589	GW	9/17/2003	8.6	4	GWMU	32.7549736	-114.004322	Yuma
97	ASE-25C	55-572101	GW	9/16/2003	4.6	4	Hargis	33.4438056	-112.010132	Maricopa
98	McClain Well	55-518520	GW	6/23/2003	2.3	4	GWMU	31.6432775	-110.651733	Santa Cruz

99	Luke AFB	gw well	GW	5/26/1999	ND	4	ASUA	33.538974	-112.364019	Maricopa

Legend:

1: Source
GW = Groundwater
IND = Industrial Facility
RE = Recharge Facility
SW = Surface Water

2. Collection Entity
ASUA = Arizona Small Utilities Association
COP = City of Phoenix
EPA = Environmental Protection Agency
GEO = GeoMatrix
Hargis = Hargis and Associates
UPCO = Universal Propulsion Company
URS = URS Greiner